The JUNE, 1932

JUN 2 1932

Heating · Piping and Air Conditioning

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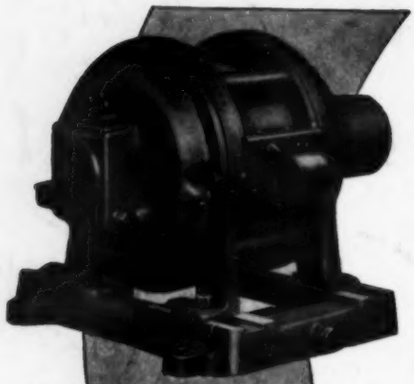
» » » *and the* Journal Section *of the* American Society of Heating and Ventilating Engineers

Heating·Piping
and Air Conditioning

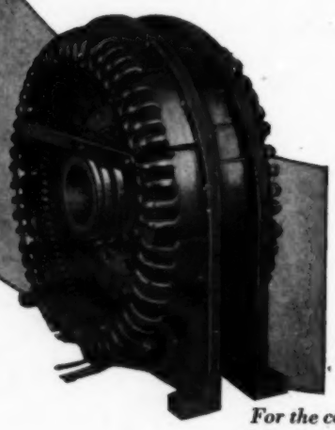
IT WILL PAY YOU TO OPEN THIS DOOR

If you have a drive problem for an air conditioning plant . . .



For the pump, a G-E quiet-operating 3- to 10-hp. induction motor

For the fan, a G-E quiet-operating 20- to 50-hp. induction motor



For the compressor, a G-E synchronous motor

These G-E motors are used for air-conditioning plant applications, and are representative of the care and experience that make every G-E motor right for the job.

THE motor backed by the adequate service facilities of General Electric is always a good investment. It is carefully designed and manufactured to stay on the job, and if your G-E motor should need service, you'll find adequate G-E facilities almost "around the corner."

General Electric motors have a proved reputation for precision in mechanical and electrical design, for excellence of materials . . . for every contributing factor that makes for unquestioned dependability.

Whatever your drive problem for unit heaters or coolers, fans, blowers, humidifiers, air filters, pumps, refrigeration, etc., we can supply the *right* motor —fractional- or integral-horsepower — and the *right* control for manual or automatic operation. Ask your nearest G-E office for complete information, or, if more convenient, address General Electric Company, Industrial Department, Schenectady, New York.

200-597

GENERAL ELECTRIC

Call the Roll of American Industries

New Plant of Borden's Farm Products Company of Illinois equipped with Byers Genuine Wrought Iron Pipe

New BORDEN Plant uses BYERS Genuine Wrought Iron Pipe to prevent replacement costs

LEADING plant engineers agree that frequent pipe replacement caused by excessive corrosion is an unnecessary waste. Hence they take steps to prevent this waste at the outset by specifying Byers Genuine Wrought Iron Pipe. An example of this engineering forethought is the new, most modern Borden Plant in Chicago where Byers Pipe is used in many services.

Offering supreme resistance to corrosion, pipe of Byers Genuine Wrought Iron by far outlasts pipe of less durable metal. Therefore the necessity of frequent pipe replacements, involving delay and large money expenditure, is avoided. How vital these savings are to today's slimmer operating budgets!

Byers Special Bending Pipe—a wrought iron pipe plus bendability, is winning acclaim among refrigeration engineers. Write for Bending Pipe Bulletin.

Why not investigate the economies you can achieve through the use of Byers Genuine Wrought Iron Pipe? Countless service records point the places where the use of Genuine Wrought Iron is a true economy. Let a Byers representative show you how Byers "pipe prescription," based on an analysis of your piping requirements, puts the right piping material in the right place. It puts Byers Genuine Wrought Iron Pipe where corrosion demands. And that means that Byers Pipe can often be used instead of more expensive piping, thus providing an additional economy for you. A. M. BYERS COMPANY, Pittsburgh, Pa., Established, 1864.

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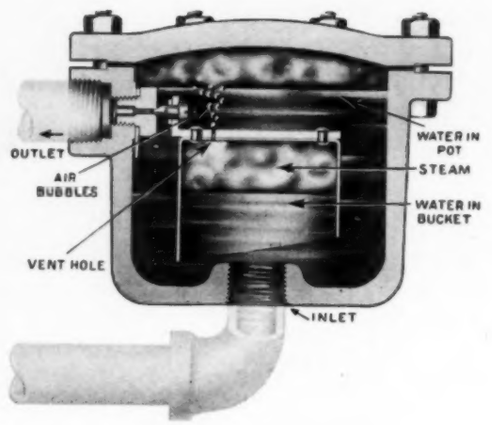
Now it's cheaper to drain small steam units

THE last reason for putting up with the inefficiency, waste, and air binding of wet steam in small steam units is gone. Draining them has been made economical and practical by the new series of Crane inverted open float steam traps.

The operation of these traps is simple in the extreme. Condensation flows up into the trap until the body is full; then it is automatically discharged through a valve in the top. When no more condensation enters, the float becomes buoyant, closes the valve and stops the discharge until an accumulation of condensation causes the valve to reopen. This cycle of operation is so instantaneous that practically all danger of wire drawing is eliminated.

These traps cost very little to install, and more than pay for maintenance with savings. When any slight adjustment is needed, simply removing the cap makes all parts accessible; there is no piping to disconnect. Write for circular No. 242-A. It gives all the details.



Sectional view of the new Crane inverted open float trap No. 981. These traps are made in ½" and ¾" sizes.

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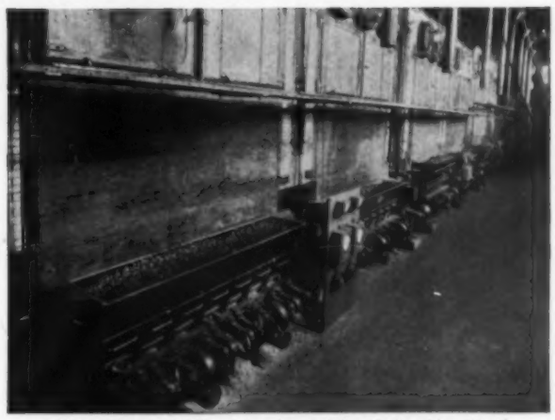
FEDERAL, STATE AND MUNICIPAL

WORK



United States Military Academy, West Point, New York

Architects, Consulting Engineers, Officials, and Contractors, charged with responsibility for the selection of equipment for PUBLIC WORK, have approved DETROIT STOKERS. The record for satisfactory, continuous performance, with bituminous coal, available in various sections is acknowledged. Distinctive features of design and application, embodied in DETROIT STOKERS represent over thirty years experience in exclusive stoker manufacture. Thousands in operation. There is a DETROIT STOKER for every service.

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U. S. Veterans Hospital . Canandaigua, N.Y.
U. S. Veterans Hospital . Chillicothe, O.
U. S. Veterans Hospital . Columbia, S. C.
U. S. Veterans Hospital . Battle Creek, Mich.
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Federal Reserve Bank . . St. Louis, Mo.
Walter Reed Hospital . Washington, D. C.
St. Elizabeths Hospital . Washington, D. C.
U. S. Military Academy . West Point, N. Y.

STATE

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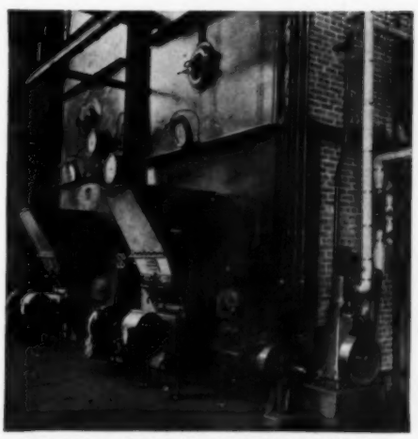
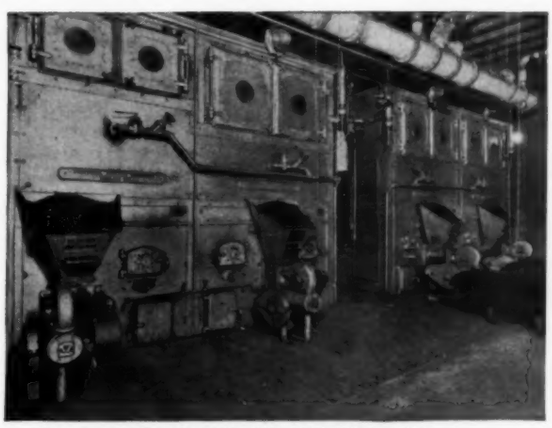
State Institution for Feeble Minded . . Columbus, Ohio
State Teachers College . E. Radford, Virginia
State Teachers College . Farmville, Virginia
State Hospital . . Traverse City, Michigan
State Hospital . . . . Pontiac, Michigan
Colo. General Hospital . Denver, Colorado



Napoleon, Ohio—Municipal Water Works

State Hospital—Pontiac, Michigan



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MUNICIPAL

Cincinnati City Hall . Cincinnati, O.
District Jail . . Washington, D. C.
St. Louis Public Library . St. Louis, Mo.
Herman Kiefer Hospital . Detroit, Mich.
New York Penitentiary, Rikers Is., N. Y.
Municipal Plant . Penn Yan, N. Y.
Jackson Water Works . Jackson, Mich.
General Hospital, Minneapolis, Minn.
Municipal Plant . . Montpelier, O.
Oliver Water Works, South Bend, Ind.
Municipal Plant . Nicholasville, Ky.
City Hospital . . Springfield, O.
Water Works . Benton Harbor, Mich.
Lighting Plant . . Milford, Del.
General Hospital . Ashtabula, O.
Light & Water Works . Dover, Del.
Buffalo City Hospital, Buffalo, N. Y.
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General Hospital . Jamestown, N. Y.

WRITE FOR BULLETIN 878

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28 *tons* LESS *the following year*

33 truck loads of coal one year—next year five less—a saving of 28 tons in the fuel bill accomplished with no other changes than installing Barnes & Jones traps on all radiators. Here's what they said:

"You may be interested to know that before your traps were installed we burned an average of 198 tons of coal per year. After installing Barnes & Jones traps on the return lines of all our radiators (no other changes were made), we are burning only 170 tons—a net saving of 28 tons yearly."

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354

Every year thousands of miles of pipe are hidden behind walls in buildings of every kind—hidden and forgotten. Behind the plaster, plumbing and heating lines form a veritable maze of pipe.

As a contractor, your duty is to install only the best pipe that the money allotted will buy. The selection is your responsibility, and, once the pipe is in service, you can do no more. Yet, over every line you can place a guard of safety—the name Republic on the pipe.

Republic Steel Pipe has a heritage. Its open-hearth steel is the best that fine materials and experienced steel men can make. Welding, threading and testing are serious operations. The result is pipe that stands the test of service no matter how severe—and the name Republic on every length of pipe stands guard for your protection.

REPUBLIC STEEL CORPORATION

GENERAL OFFICES YOUNGSTOWN, OHIO

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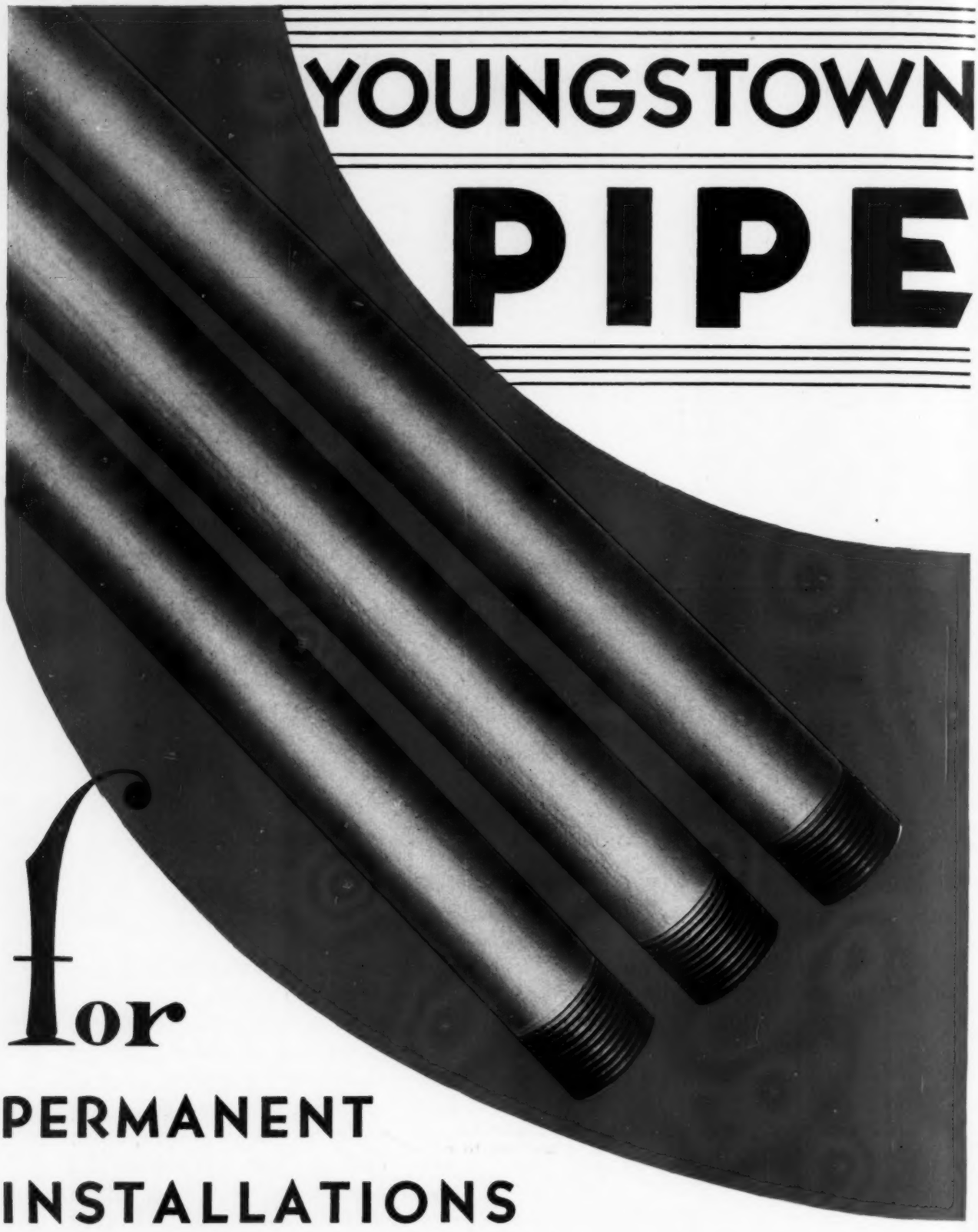

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PERMANENT INSTALLATIONS

THE YOUNGSTOWN SHEET & TUBE CO.
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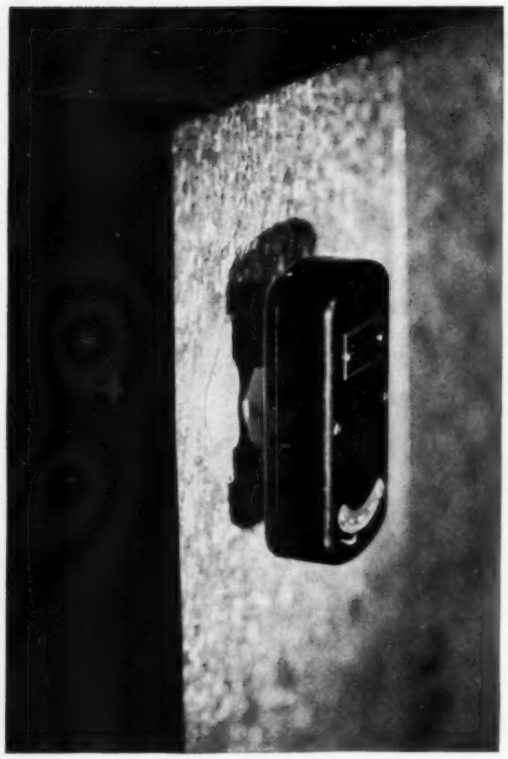
THE BARBER-COLMAN ELECTRIC SYSTEM OF TEMPERATURE CONTROL



for TEMPERATURE CONTROL in Ducts— *by Electricity*

THIS duct thermostat is a sensitive, accurate, dependable instrument. Its principal use is for governing the action of damper controllers and valves on plenum, blast and split systems where the temperature of the air must be held accurately at various levels in the several stages of the system. In such installations the Barber-Colman Duct Thermostat performs excellent service and is available in a sufficiently wide variety of models, having different temperature ranges, so that it can be supplied to meet any of the conditions found in present-day heating, ventilating and air-conditioning installations.

"Immersion" models are available for use in tanks, pipes, vats, etc., containing liquids. We also supply a Surface Thermostat which will perform the same functions and does not require puncturing the container for the introduction of the sensitive element, as it is designed to be strapped or clamped directly on the surface. It is distinguished by a rapid response to temperature changes and by a small differential.

These thermostats are of the customary three-wire, open contact type with a bimetal sensitive element, and are designed and constructed to give accurate and dependable service throughout a long and trouble-free life. It is impossible here to tell of the many uses to which Barber-Colman Insertion and Immersion Thermostats may be put, but we will be glad to assist with any problems you may have involving such controls. Our Engineering Department is qualified to make definite recommendations.

A 48-page catalog describing the Barber-Colman Electric System of Temperature Control will be mailed upon request. Write for your copy today.

BARBER-COLMAN COMPANY
ROCKFORD, ILLINOIS, U. S. A.

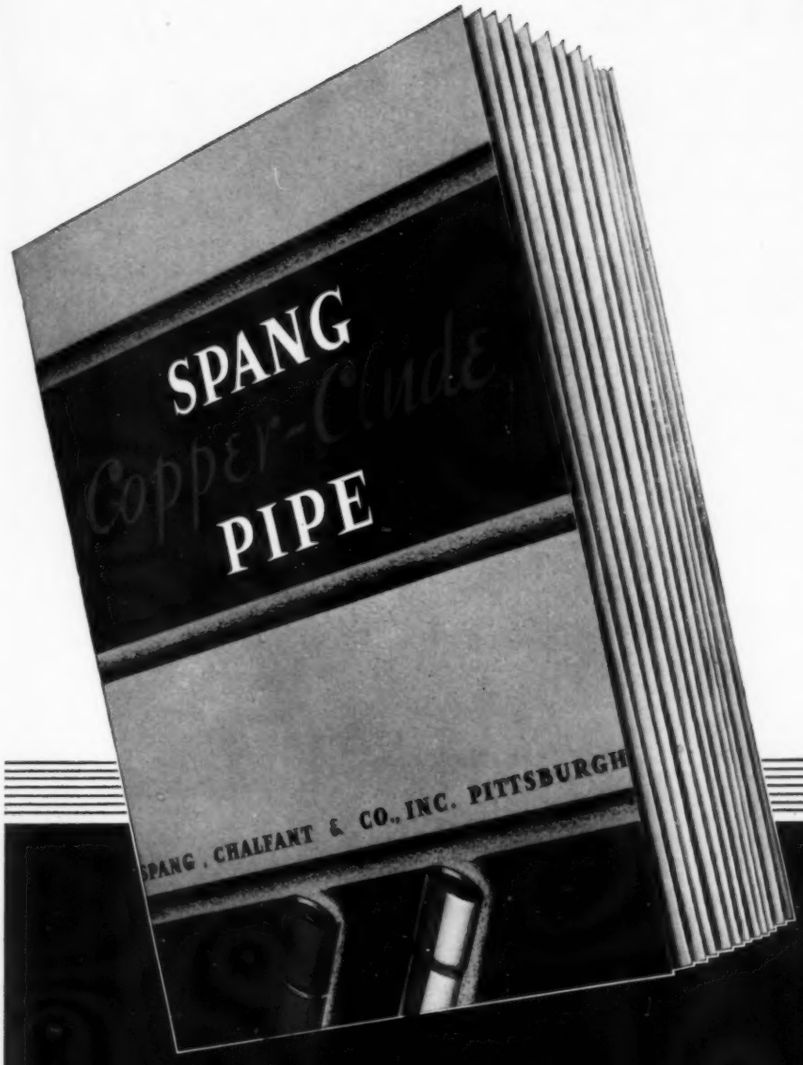
The first successful ELECTRIC SYSTEM of Room Temperature Control

RUMORS

Rumors spread, and when there is a similarity of names, they lead to confusion. To correct an impression that is a result of rumor, we make this announcement:

The York Ice Machinery Corporation, York, Pa., is in no way connected, either financially or otherwise, with the Carrier-York Corporation, Philadelphia, Pa.

YORK ICE MACHINERY CORPORATION
YORK, PENNSYLVANIA



If you want the last word in copper-bearing pipe ...*send for this booklet.*

A handbook of valuable information—this publication deserves a foremost place among your data books . . . contains a brief but comprehensive summary of the development, properties and applications of Copper-Clude—a modern achievement in corrosion resisting pipe—a pipe that strikes an ideal balance between initial cost and ultimate service in all tubular installations exposed to atmospheric corrosions.

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Bonney Weldolets and Thredolets offer distinct advantages where branch connections must be made on piping already installed. These fittings are welded directly to the main pipe in the desired location . . . and the junction completed by welding or screwing the branch pipe into position.

No cutting, or fitting, or removal of sections of the main pipe . . . no unnecessary excavation . . . no lining up . . . no templets . . . no burdensome handling of the main pipe . . . in fact, no delays, the system is again in operation in a surprisingly short period.

The intersections are stronger than the pipe itself. Turbulence and friction are reduced. The inside of the junction is in full view. Warping of the main pipe is eliminated. And the fittings are priced for economy.

Gas, District Heating and Water Companies use Weldolets and Thredolets on service connections . . . Industries everywhere find wide use for them on maintenance jobs, new construction and manufactured products. Give Weldolets and Thredolets careful consideration. You'll find many jobs on which they can be used to advantage.

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WELDOLETS · THREDOLETS

Making a difficult installation of a branch easy by using a Weldolet. All of the welding on this job was done with the main pipe in position. The fitting was used to connect a 6-in. water regulator line into an existing 8-in. boiler feed line. Operating pressure, 600 lb. per square inch at 300 deg. F. Notice the welder with square on the face of the welding neck flange. No distortion or warping was evident.

GET THIS NEW BULLETIN

Fill in and mail the coupon below for bulletin WT17 which completely describes and illustrates Bonney Weldolets and Thredolets. This bulletin is just off the press and contains valuable working data. Get your copy today.

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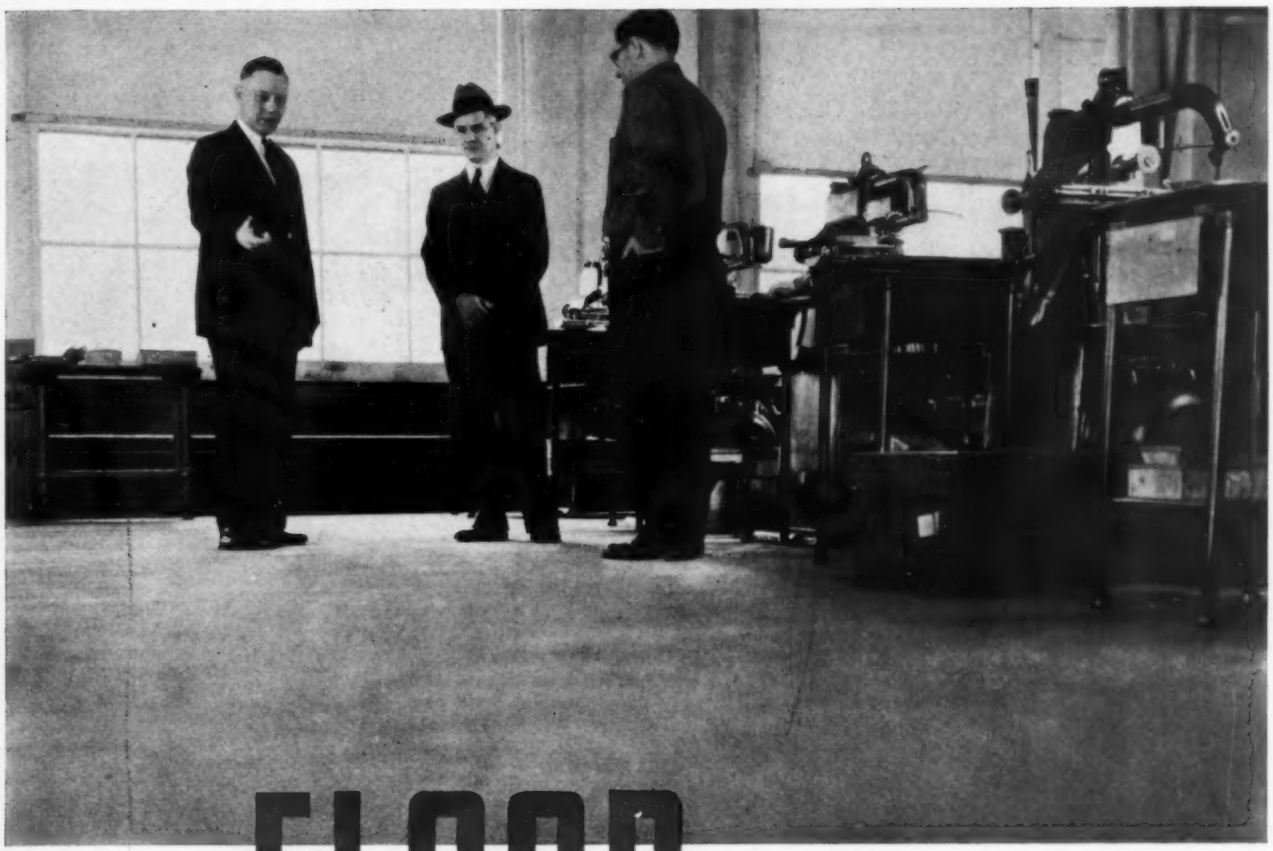
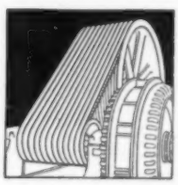


"Now we have FLOOR SPACE for these new machines"

"You'd hardly believe how much space we've saved by installing Dayton Cog-Belt Drives. No problem now to find space for those new machines!"

Expressions like these come from literally scores of plants where Dayton Cog-Belt Drives are used. These modern drives released enough floor space for one concern to save the cost of a new building. Besides saving floor space, the flexibility and general appearance of the plant alone would be sufficient reason for installing Dayton Cog-Belt Drives, says another plant executive. And here are some of the reasons why!

Dayton Cog-Belts are "built to bend." Their patented cog construction and crosswise rigidity make them far more flexible . . . with no distortion, no wrinkling or buckling. And with greater flexibility, smaller pulleys are used. Center-to-center distances are shorter . . . *less floor space required.* All this with less tension . . . less wear on the bearings. For the *die-cut sides* of the belts fit the V-groove pulleys . . . *accurately* and *permanently.* Their raw edge contact surface guarantees an unyielding grip. No slipping, no sliding. Machines run more smoothly. Speeds are positive. Power is saved. Production is increased.



And because Dayton Cog-Belts are "built to bend," *their life is two and three times longer* than that of ordinary belts. Maintenance expense is lower. There's no "dressing" or lubrication . . . fewer repairs and replacements . . . seldom any adjustments. Belt cost is reduced to an astonishing degree. But there's more yet to tell. It will pay you to get ALL the facts. They'll be sent to you promptly if you'll write or wire.

THE DAYTON RUBBER MFG. CO.
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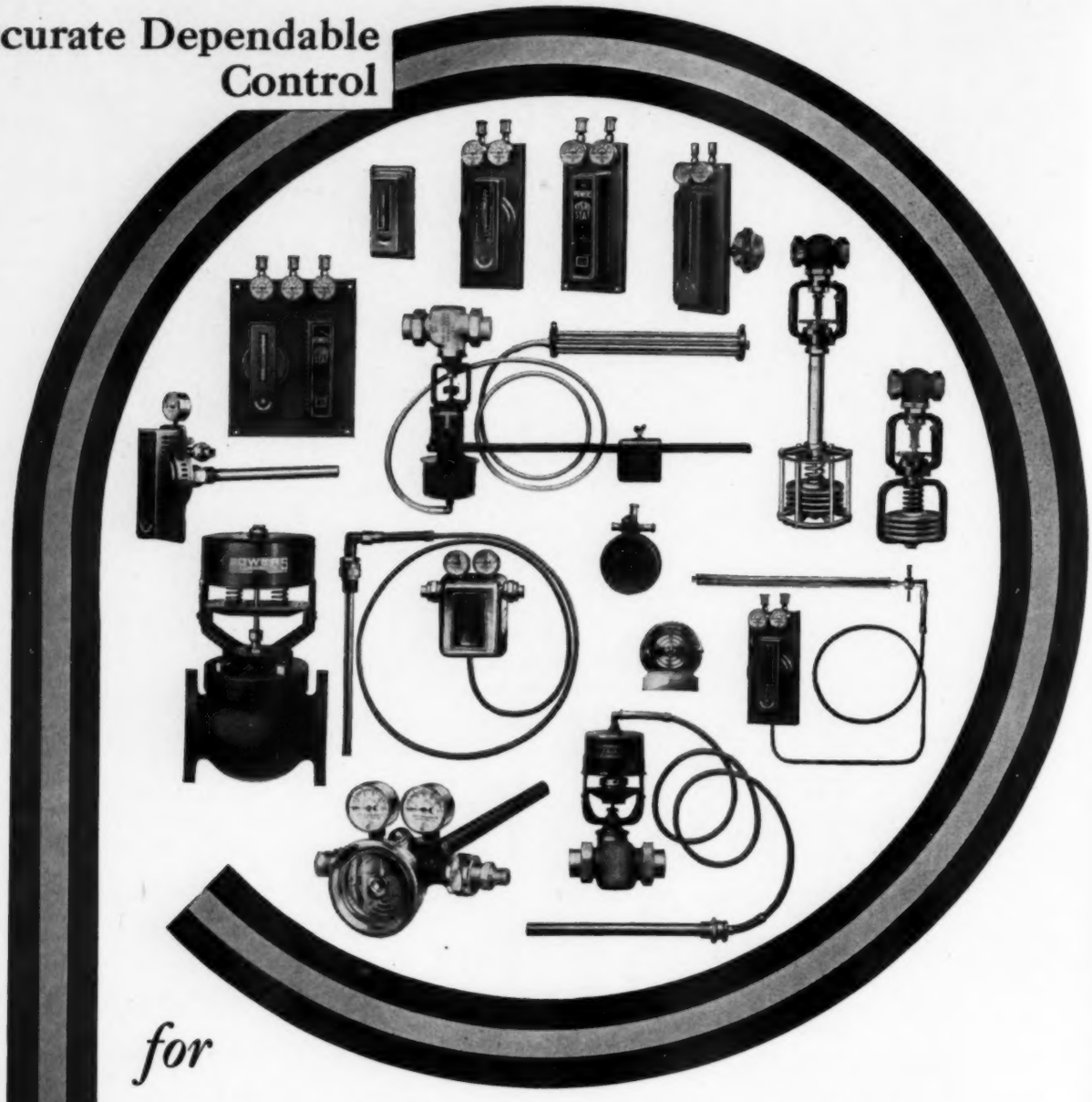
Factory Distributors in Principal Cities and all Westinghouse Electric and Manufacturing Company Sales Offices

Dayton
COG-BELT DRIVES

Accurate Dependable Control



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THERMOSTATS—both graduated and positive acting for dry bulb control. **Hygrostats**—both pneumatic and electric for humidity control. **Self Contained Regulators**—complete line for control of air and liquid temperatures. **Brine Control**—regulators for control of brine circulating systems. **Dampers**—both single and multiple blade, with or without operating diaphragm motors. **Diaphragm Valves**—All metal construction, including three-way valves, brine control valves, etc., etc. **Accessories**—Automatic Water Pan for wet bulb control, Relays, Pressure Reducing Valves, Pneumatic Switches, Dial Thermometers, etc., etc. ***Write for Bulletin No. 251,*** which describes these Instruments.

40 years of specialization in temperature control

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OWERS

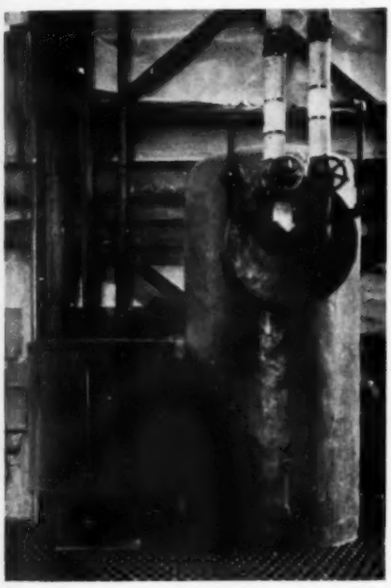
REGULATOR COMPANY

The EDITOR'S PAGE

Heating · Piping and Air Conditioning

THIS MONTH—

Clyde R. Hoey, Jr., describes the method of piping a boiler blow-down in the plant of the Champion Fibre Company in his article on page 416. A heat saving amounting



to $11.64 is made every day through its use, and the article shows how this saving is computed. Two drawings show details of the system and the arrangement of the piping. The illustration here shows the flash and surge tanks.

Proper refrigeration is one of the most important parts of good bread-making, and consequently the refrigeration piping in a modern bakery is one of the most important parts of the mechanical equipment. Arthur W. Archer, in a carefully written and illustrated article in this issue, describes an effective refrigeration piping lay-out in a modern bakery.

There are a number of post offices being planned or constructed at the present time; one of the outstanding jobs is the new mail-handling center in Chicago, the cornerstone of which was laid a few days ago. Already, world-wide interest on the part of engineers and postal authorities has been shown in this structure. George W. Ott describes the method of heating this great industrial work-space in his article in this issue; next month he will describe the ventilating.

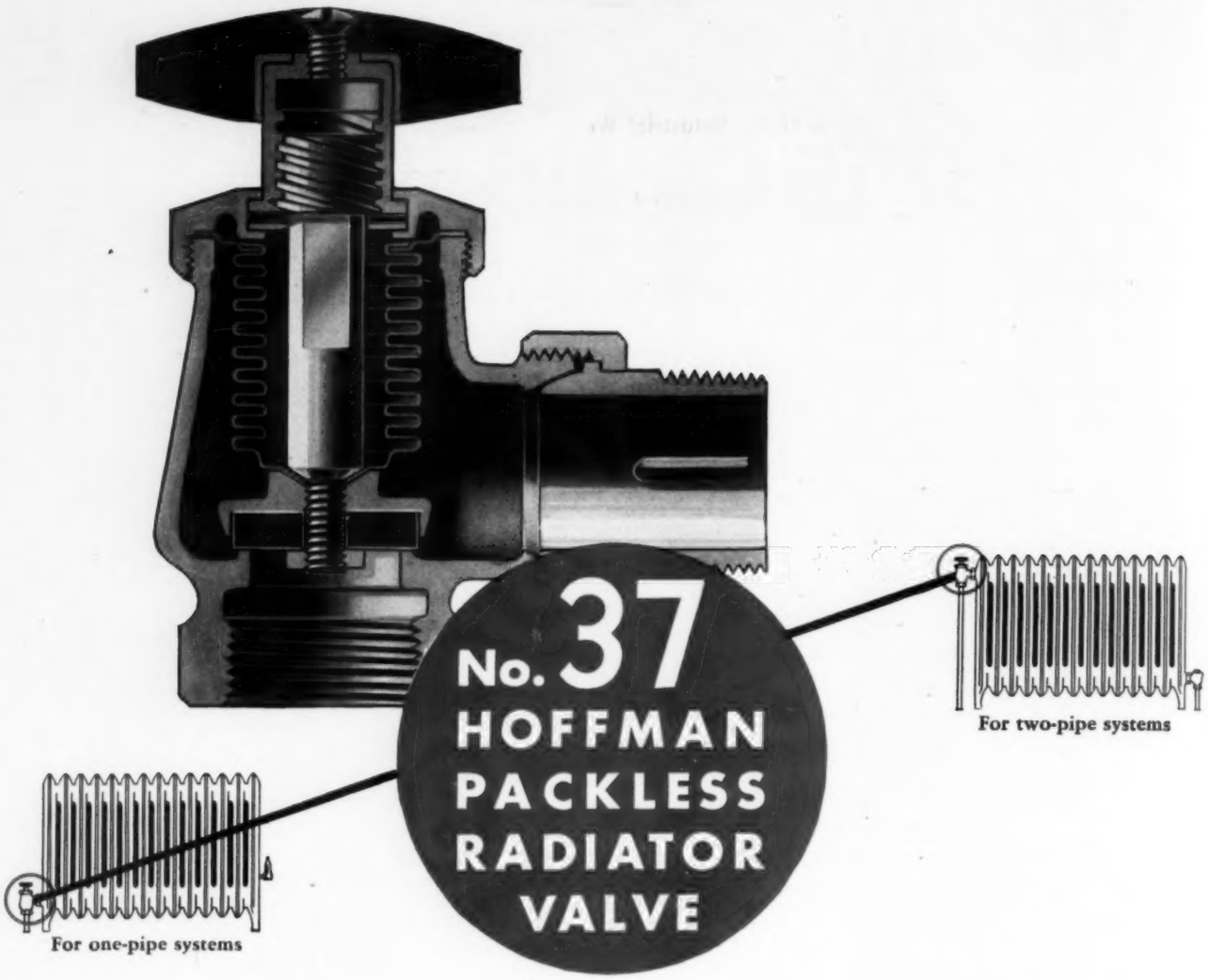
Use of the so-called inverted-refrigeration cycle for summer-and-winter air-conditioning plants has of late attracted considerable attention. Performance of such plants is greatly influenced by the thermodynamic cycle of operations, a subject to which H. J. Stoever devotes his paper, which is published on page 412. In it he outlines an ideal cycle and shows a method of approaching it in practice.

Ice as the medium for supplying refrigerating effect has applications to a number of types of air-conditioning installations; not the least important part of such a system is the water cooler. Clifford F. Holske, test engineer familiar with a number of ice-cooled jobs, writes on the construction of water coolers and the piping of the cold water in an article starting on page 405. A 6-ton bunker in a restaurant is shown here.

NEXT MONTH—

"Leak-Tight Joints—600 Lb. to 550,000 Lb. per Sq. In." is the intriguing title of an article which has been prepared by F. E. Wertheim and which will appear in next month's HEATING, PIPING AND AIR CONDITIONING. The purpose of this article is to discuss various types of joints which have successfully met the conditions imposed by different classes of service.

How waste heat from a continuous pottery kiln is used for factory heating and drying in the plant of the Gem Clay Forming Company, Sebring, Ohio, will be described in an article by H. C. Weller, industrial engineer, next month. In addition to describing the system installed, data on determination of the available heat in flue gases are included and a discussion of comfort and health in plants is given.



No leakage . . . no "creep" . . . no bellows strain

Judge the new No. 37 Hoffman Valve from every angle . . . and you'll agree that here is the last word in Packless Valve design and workmanship!

Note particularly the bellows—hydraulically formed and *tested in the making*. It's your guarantee against steam and water leakage—against loss of efficiency in vacuum systems from in-leaking air. The generous proportions of the bellows permits high lift from the seat without strain.

Torsional stress can never cause bellows failure in a No. 37 Hoffman Valve. The flat-sided valve stem moves through a slot in the bonnet, positively preventing any twisting action on the bellows.

Quick opening—one turn fully opens or closes the valve. No "creeping" of the valve from its seat—a friction brake overcomes this common trouble.

Efficient, durable and handsomely finished, the No. 37 Hoffman Valve has won the unqualified approval of exacting engineers and contractors. See your jobber or write for specifications, dimensions and prices.

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MAKERS OF HOFFMAN VENTING VALVES, HOFFMAN CONTROLLED HEAT AND HOFFMAN ECONOMY PUMPS . . DEPT. FG-36 WATERBURY, CONN.

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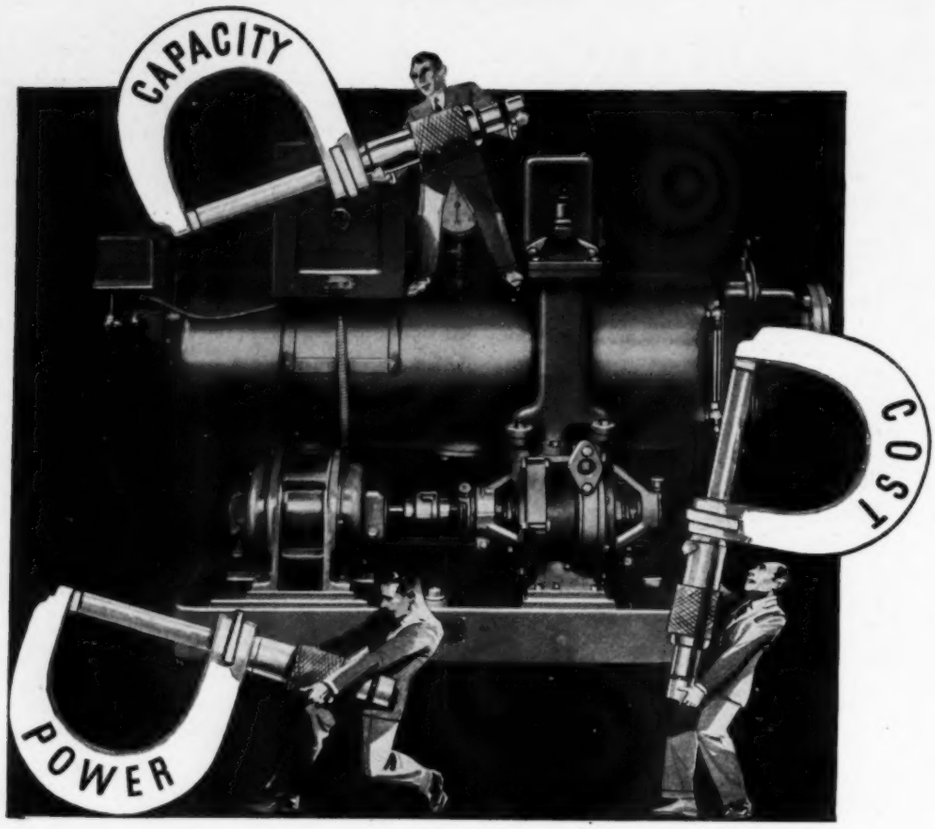

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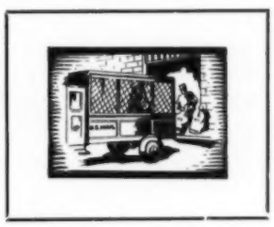
Heating · Piping and Air Conditioning

Vol. IV June, 1932 No. 6

New Post Office a Great Industrial Work-Space—Heated by Steam and Hot Water

By George W. Ott*

ALL the steam for the new Chicago post office [1] is to be purchased from the new Union Station power plant being erected ¾ of a mile south of the post office on the south branch of the Chicago river. The steam will be brought to the pump room, located below the tracks in the southwest corner of the building, at 100-lb. gage pressure, and then piped at high pressure or reduced to the desired pressures, and run to the various equipment throughout the building.



Condensation will be returned to the mains of the Union Station company, after having passed through a coil in the economizer, where it is to be used to preheat the make-up water for the domestic hot water supply.

In providing for Congress street to run through, the post office building is cut into two parts in the first story and the south portion will be used for loading trucks, thus leaving almost two-thirds of the first story open and exposed to the elements; the building being built over the tracks of the Union Station leaves the space below the first floor open and exposed to the cold. For these two reasons a forced-circulation hot-water heating system is to be used for the first and second stories; for the third story and above a two-pipe vacuum steam heating system is to be employed.

Heat loss factors used were 0.44 Btu for floor, 0.33 Btu for ceiling and roof, 0.24 Btu for wall, 1.0 Btu for glass per sq. ft. and 0.03 Btu per cu. ft. of contents per degree difference in temperature per hr.

For hot water, 180 Btu per square foot of heating surface per hr., and for steam, 240 Btu per sq. ft. of heating surface per hr. were used as the bases for determining the amount of radiation. The temperature range was taken from minus 10 F outside to plus 70 F inside. In figuring infiltration loss 1½ changes per hr. for a distance 25 ft. back from the outside wall was assumed.

* Mechanical department, Graham, Anderson, Probst & White, architects, Chicago, Ill.

[1] The new United States post office for Chicago is being erected over the Union Station tracks on a site bounded by Van Buren street on the north, Canal street on the west, Harrison street on the south and a private drive on the east. The site has a ground area of approximately 6.29 acres, being 344 ft. east and west by 796 ft. north and south. Provisions have been made for running Congress street through the building, but until the city makes certain contemplated improvements so that this will be necessary, the space will be used as a private driveway by the post office.

On the eastern part of the site there is now a 6-story building, with additional floors at the track level and a basement below, which is used as a parcel post station. This building is to be absorbed in the new structure by wrecking approximately 140 ft. from both the north and south ends to make way for the corner pylons. The wall on the east is to be removed and a new one erected to conform to the architecture of the new building. When completed the two structures will have the appearance of a single large building.

The north end of the building is 12 stories high in the center and is flanked on both sides by the 15-story corner pylons. In the first and second stories will be housed the wholesale and retail stamp sections, the general delivery, lock box and registered mail sections and the public parcel post lobby. This is the only portion of the building which is normally accessible to the public.

The remaining stories at the north end of the building will house various government offices which now occupy spaces in numerous loop buildings. South of this will be the post office work space,—the great industrial center which is de-

The new Chicago post office—now being erected—will be one of the greatest mail-handling centers in the world—if not the greatest. Engineers have already shown a keen interest in the mechanical and structural facilities of this building, which primarily is a large industrial work-space.

The Chicago post office has for years been a sort of "practical laboratory" in mail-handling; many developments which have increased the efficiency of the postal service have originated and been improved there. The equipment being installed in the present structure, therefore, represents careful study of the requirements of this type of building. The author, who is thoroughly familiar with the design, describes the heating system in this article.

ARCHITECT'S DRAWING OF THE NEW CHICAGO POST OFFICE, PLANNED TO BE ONE OF THE FINEST IN THE WORLD

Graham, Anderson, Probst & White, architects; John Griffiths & Son Company, general contractors; H. P. Reger Company, heating contractors; Zack Company, Inc., ventilating contractors.

The direct radiation is to be of cast iron, narrow-tube-type hot-water pattern having plain surfaces; all radiators are to be legless, hung on concealed adjustable wall brackets. Each unit is to be tapped at the top for the supply and at the bottom (opposite end) for the return. The supply end of each hot-water radiator will be equipped with a graduated-dial adjustable-opening valve and on the return end with a railroad union. Each steam radiator will have a direct-controlled supply valve and a return trap. Supply and return connections to hot water radiators will be ½ in. with the valves full size of the connection. A total of 43,148 sq. ft. of direct hot-water radiation and 137,116 sq. ft. of direct steam radiation will be required to heat the building.

Sizes of connections to steam radiators are:

Up to 60 sq. ft.—¾-in. supply and ¾-in. return.
61 to 90 sq. ft.—1-in. supply and ¾-in. return.
91 to 140 sq. ft.—1¼-in. supply and ¾-in. return.
141 sq. ft. and larger—1¼-in. supply and ¾-in. return.

No supply is made smaller than ¾-in.; supply valves are full size of radiator connections; return valves for 60 sq. ft. and smaller are ½-in. and above, ¾-in.

The Hot-Water Converters and Pumps

Two converters will be used to heat the water for the hot-water system; each converter will be of sufficient capacity to take care of the entire load, leaving a spare unit for emergency; each will be of capacity to heat not less than 1,000 gal. of water per min. from 165 F with steam at 1 lb. pressure. The converters will be designed for 100-lb. working pressure, and have removable heat-

---

signed to receive and to send out a maximum of 26,000,000 pieces of first-class mail, 10,000 tons of parcel post mail and 20,000 sacks of second- and third-class mail per day. The railway mail service will be housed in the portion of the existing building which is to remain, occupying the third to sixth stories. The work space will be 9 stories in height with 12 stories in the corner pylons. The work spaces of the new portion have story heights of 19 feet, while the railway mail portion has story heights of 16 ft. The relations of the floors in these portions are shown in the section through the building.

A kitchen and cafeteria are located on the fourth floor. The unit has a capacity to serve 9,000 meals in two hours. This is spread over four lunch periods of 30 minutes each. A private dining room is provided for the officials of the post office. Locker rooms and shower baths are provided for the kitchen and cafeteria help.

The Method of Handling the Mail

Mail is brought into the building by two means (1) by automobile and (2) by the railroads, and leaves the building in the same way. Incoming mail by automobiles is brought to the second floor by means of a ramp. Here the various classes of mail are separated from the parcel post mail. The various classes of mail are then taken by elevators to the eighth story where the primary separation takes place; here it is divided into mail for cities, for states or groups of states and is then sent to other parts of the eighth floor or to the fifth floor. At this point the mail is broken into smaller divisions, that which is to go to large cities is placed in packs marked for the destinations and that which is for smaller cities and for rural districts is placed in other sacks which are broken into the necessary smaller divisions by the railway mail service. The parcel post is placed on conveyors and by means of inclined conveyors is taken to the seventh floor and separated into mail for cities, for states or groups of states and sent to other parts of the seventh floor or down to the sixth floor where the secondary separation takes place. There the parcel post mail is sacked for shipping by various railroads and from this point on follows the same course of handling as the letter mail.

After the various classes of mail and parcel post are sorted and sacked ready for distribution they are sent down to the first floor or the track level by means of spiral chutes to be placed on trucks or railroad cars. The ninth floor of the work portion is taken up by the dead letter division, nixie division, machine shops and empty equipment division.

Wherever possible to save time in handling of the mail conveyors will be installed.

ing sections constructed of seamless drawn brass tubing, in the form of U-bends. Regulation will be obtained by means of a temperature regulator. The water will be circulated by two electric-motor-driven centrifugal circulating pumps, each pump with sufficient capacity to circulate enough water for the entire system. The second pump is a stand-by unit. Each pump will have a capacity to circulate not less than 1,000 gal. of water per min. through the system against a pressure of approximately 30 lb. The system is designed for an average temperature of water of 180 F, the water leaving the converters at 195 F when the outside temperature is minus 10 F and returning to the converters at 165 F. Steam will be supplied to the converters at low temperature.

A closed expansion tank will be located in the fifth-story fan room in the south-east pylon.

24 Unit Heaters for Trucking Space

The trucking space in the south end of the second floor will be heated with 24 unit heaters supplied from the hot-water heating system. Each heater will be of a capacity not less than 81,000 Btu per hr. based on water at a temperature of 170 F with entering air temperature of 50 F. They will be of the suspended type, with non-corrosive elements, and are to withstand 250 lb. hydrostatic pressure. Motors will be fully enclosed, wound for 110 volts, single phase, 60 cycle, alternating current. All heaters will be installed so that they will deliver at any angle through an arc of 180 degrees and so arranged that they can be locked in position.

The public lobby will be warmed by means of circulating fans taking air which is already warmed from points near the ceiling and further heating it by forcing it through heaters at each side of the revolving doors and back into the lobby.

Condensate Preheats Domestic Water

Three duplex vacuum pumps will be used to remove the air and condensation from the heating system. Each will have a capacity of 300,000 sq. ft. of direct radiation when discharging against a pressure of 10 lb. per sq. in. and maintaining a vacuum of 10 in. of mercury on the heating systems. The pumps will discharge through an economizer into the receiving tank.

The economizer will be 48 in. in diameter and 13 ft. long, constructed for a hydrostatic working pressure of 250 lb. per sq. in. All of the condensate from the various heating systems connected to the vacuum pumps will be passed through the removable heating coil of the economizer and then into the receiving tank, preheating the make-up water for the domestic hot water system. The receiving tank will have a capacity of 10,000 gal. and will be supported on a platform, under which will be located the two condensate return pumps. Each pump will be of a capacity to return 300 gal. of condensate per min., which is sufficient to handle all of the condensate from the complete system, to the Union Station company's receiving tank located just outside of the pump room. The pumps will be of the centrifugal type, directly connected to motors by means of flexible couplings.

Piping Materials and Connections

All piping, except water piping which is of copper or brass, will be black welded-steel pipe or black wrought-iron pipe. The fittings will be of best quality cast iron, standard weight, steam pattern, heavily beaded. Fittings 2 in. and smaller are to be screwed while those 2½ in. and larger are to be either screwed or flanged. Eccentric reducing fittings or eccentric reducing couplings will be installed in steam and return mains to bring bottoms of mains in line and prevent pockets; eccentric fittings will not be used on hot water mains. Unions 2 in. and smaller will be of the ground joint type with hexagonal or octagonal ends. They will be either all brass or may be iron body with brass to iron seats. All unions on pipes 2½ in. and larger will be standard cast-iron flange unions with proper gaskets.

The outside steam service piping and all connections to equipment will be made with flanged fittings and valves. All high-pressure steam piping 3 in. and larger, and all hot-water heating system mains and steam piping 8 in. and larger will have flanged joints and fittings. In smaller piping flanges will be used at convenient joints to facilitate repair work. All piping in the main pipe shaft from the pump room ceiling to a point above the first floor level is inaccessible and will be installed with welded joints.

Piping Runs Exposed

All piping throughout the building will be run exposed. The supply and return risers, run-out connections to the radiators, and the radiators in the work areas are protected from damage due to mail trucks striking them by angle-iron bumper guards.

Expansion will be taken care of by corrugated copper

expansion joints designed for 150 lb. working pressure. Joints 4 in. and smaller will take care of not less than 2 in. of expansion and those larger than 4 in. will take care of not less than 3 in. of expansion. All steam supply and return risers not connected to radiators will be anchored at the first and ninth floors with one expansion joint at the fifth floor. Steam supply and return risers connected to radiators will be anchored at the fourth and eighth floors with an expansion joint at the fifth-story ceiling. Main steam supply and return pipes will be pitched not less than ¼ in. in 10 ft. and all small piping not less than 1 in. in 10 ft.; hot-water supply and return mains will be run level.

All branches to the hot-water heating supply and return mains will be valved with two gate valves. The valve nearest the main will be an ordinary gate valve used for shutting off the flow of water and the other will be a lock-shield valve for regulating the flow to or from the riser or branch mains and will be permanently set in the proper location. All branch connections to the steam supply and return mains will be valved next to the mains.

The Pressure-Reducing Valves

The pressure-reducing valves will be the double seat, balanced lever, diaphragm type, designed and connected so that the delivery pressure will be practically constant regardless of the amount of steam being used. All pressure-reducing valves will be adjustable so that the pressure may be varied, the steam being brought up to the valves at approximately 100 lb. pressure.

Valves supplying the water heaters at high pressure will be set to deliver 40 lb. pressure. The pressure for steam heating will be 1 lb. and the steam for fan blast radiation will be delivered at 5 lb.

There will be, in every case, two pressure-reducing valves in parallel. One of the valves will be of a capacity to supply approximately one-third and the other, two-thirds of the entire load on the particular system being served. Between the pressure-reducing valve and the globe valve on the high-pressure side of the pressure-reducing valve there will be installed a pneumatic valve controlled from the engineer's office in the pump room.

Method of Isolating Machinery

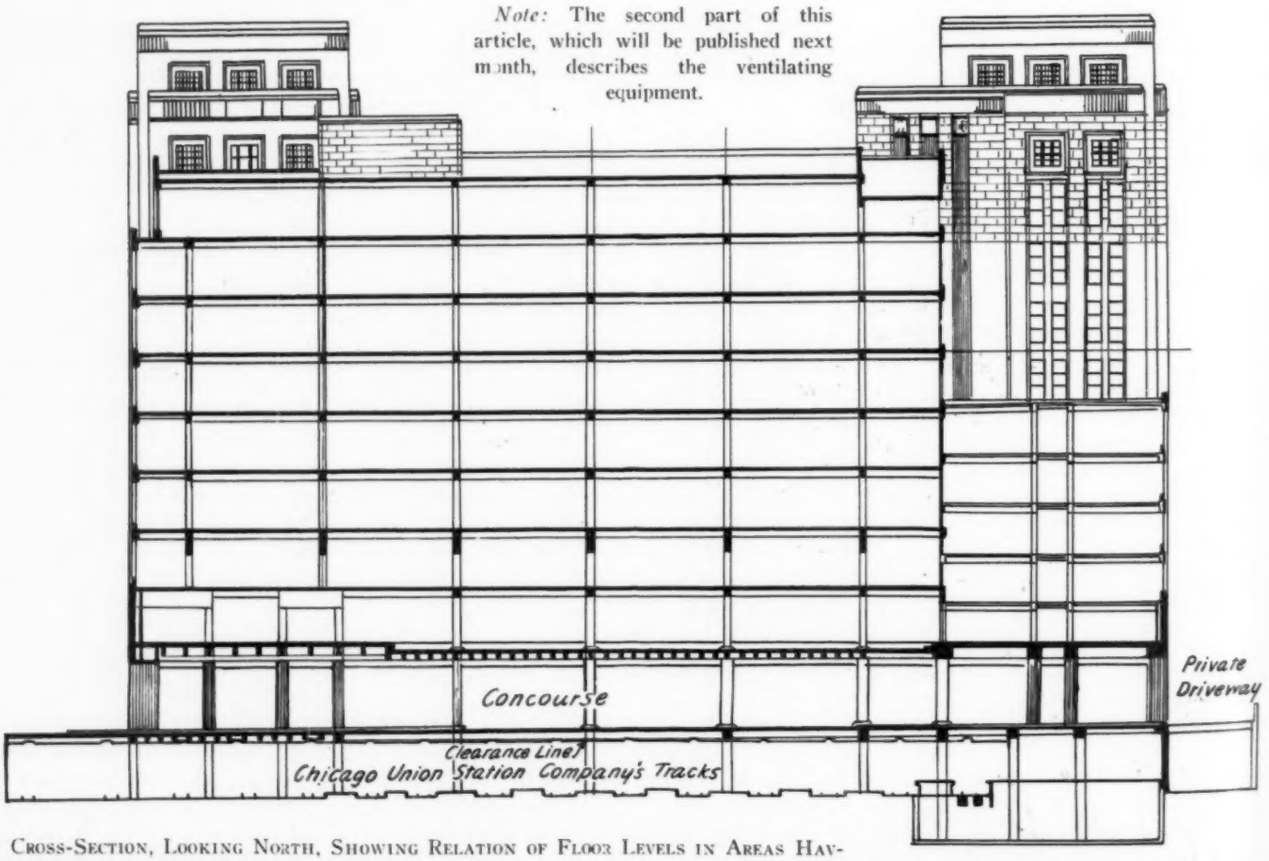
All pieces of machinery will be set on concrete foundations, and held in place by anchor bolts with pipe sleeves and bottom plates built into foundations. All pumps, compressors, fans, etc., will be isolated from the slab or other building construction with not less than 3 in. of special isolating cork board.

Supports for hot-water heaters, economizer tank, make-up tank, converters, condensate-receiving tank, fire-pump cushion tank, air tanks and other light apparatus will rest on the finished floor.

Insulating the Piping

All non-conductive covering will be of standard thickness and will be sectional removable. Covering for pipes will be of 85 per cent magnesia or of mineral felt. Covering for fittings and valves will be asbestos, mag-

Note: The second part of this article, which will be published next month, describes the ventilating equipment.



Cross-Section, Looking North, Showing Relation of Floor Levels in Areas Having Different Story Heights. The Space Under the First Floor Is Open and Exposed to the Outside

nesia or mineral felt plaster insulating material. All sectional covering will have canvas jackets and brass-lacquered bands spaced not over 18 in. apart. There will be three bands installed at each tee and two bands at each elbow.

Mineral felt covering will be inorganic and chemically inert and will be treated so that it is vermin proof and fireproof. Asbestos will be long fibre, best quality and the plastic insulating material will contain at least 85 per cent asbestos combined with other suitable insulating and binding materials to provide a high insulating value and one which will mix easily and adhere to hot surfaces. Magnesia plastic insulating material will be of substantially the same composition as the sectional pipe coverings. Plastic covering on valves and fittings will have canvas jackets and bands the same as pipe covering.

This article describes the construction of typical ice bunkers for air-conditioning systems using blocks of ice as the cooling medium. Details of bunkers in various installations are shown.

Water Coolers *for* Air-Conditioning Systems Using Ice

By Clifford F. Holske*

SIZE and capacity of the water cooler needed for an air conditioning installation in which ice is used as the refrigerating medium can be readily calculated from the heat load, the maximum figure being used as a basis. As an example, consider a building which, under extreme conditions, requires refrigeration at the rate of 10 tons per day, in which the cooling system is to be operated for not more than ten hours daily. The water-cooler capacity may be taken as the refrigeration required per hour multiplied by the number of hours of operation, or $10/24 \times 10 = 4.16$ tons of ice per operating day. This is of course a minimum figure and where possible it is desirable to increase this by 30 to 50% because re-icing may not always be accomplished at the exact time desired and cooling effect obtainable is dependent to a great extent upon the amount of ice surface exposed to the water so that satisfactory cooling will not be obtained when the bunker contains, say, less than 10 per cent of its total ice capacity.

Another way to provide for this is to make the water cooler large enough to hold the ice needed for 30 consecutive hours, starting from the normal time for icing. In the case in question, if it is assumed that the cooler is normally iced at the start of the maximum operating period the equation becomes $10/24 \times 16$, or 6.6 tons.

In classes of work where the operating period does not begin until late in the day an allowance of this type may be unnecessary as there is ample time to arrange for re-icing before the operating period. In general this method should be followed with the smaller installations, as the necessity for more than one delivery per day will usually result in a higher unit price for ice than would otherwise be obtained. Where the ice consumption exceeds the capacity of one truck (approx. 8 tons) this factor may be disregarded. To save labor and keep the unit ice price at a minimum, ice bunkers over one ton in capacity should be arranged to accommodate full-sized ice blocks. The standard 300-lb. ice blocks are approximately $11 \times 22 \times 42$ in., the 400-lb. blocks $11 \times 22 \times 56$ in.

In systems using an air washer, the water cooler can be placed below the washer as in Fig. 1. By using this arrangement the system can be operated with one circulating pump; two would be required if the washer were located below the cooler.

The water cooler itself may consist of an insulated and water-proofed compartment, the bottom of which serves as a collecting tank for the cooled water. A sub-

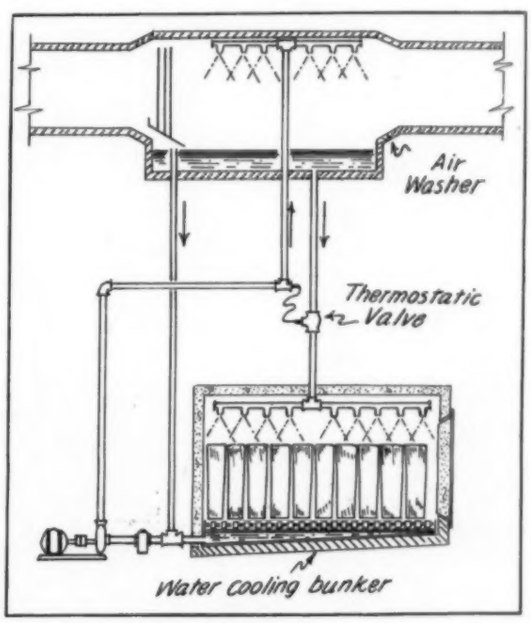


FIG. 1—AN ICE-COOLED AIR CONDITIONER

* Test engineer, American Ice Company, New York City.

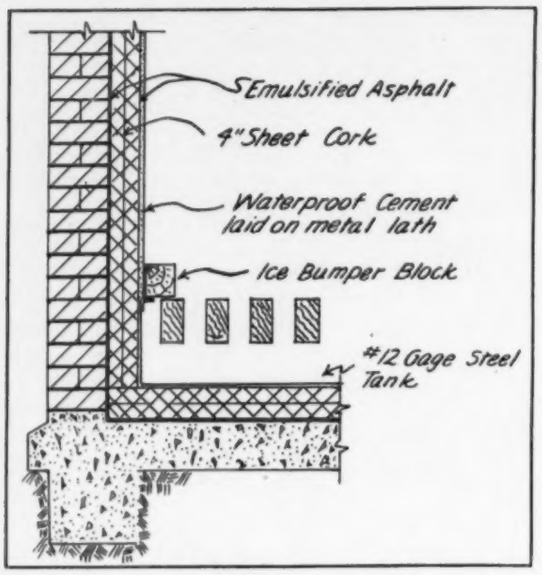
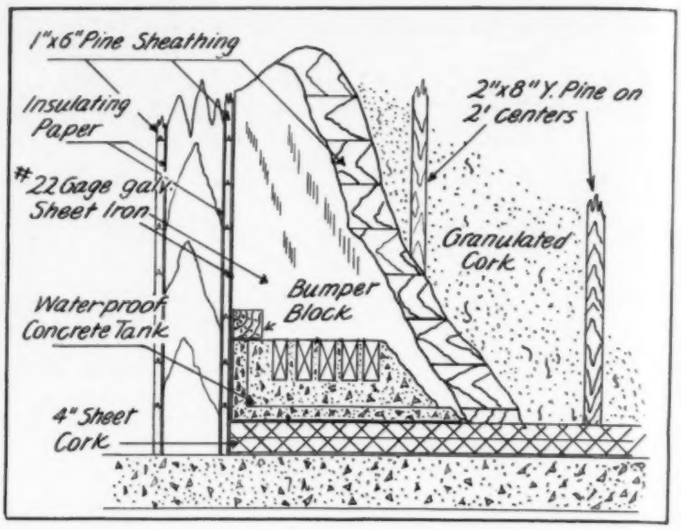


FIG. 2—DETAILS OF SHEET CORK INSULATION FOR ICE BUNKER

FIG. 3—CONCRETE WATER-COOLING TANK WITH GRANULATED CORK INSULATION



stantial wooden grating is provided to support the ice, and a system of sprays at the ceiling distributes the warm water from the air washer over the ice. Low-head, high-capacity sprays may be used as the object is even distribution of the water.

Sheet cork, rock wool, etc., may be used for the insulation, an economical thickness for the temperatures usually required being approximately four inches. The insulation should be properly protected from the splash of the sprays either by some such means as a galvanized sheet iron lining or a waterproof cement coating set in wire lath. Fig. 2 shows details of an insulation of this type as applied to an existing brick wall. The collecting tank may be galvanized iron as shown, or waterproof cement.

Another form of insulation is shown in Fig. 3. A framework of 2×8 in. studs is erected and sheathed over, insulating paper being applied before the tongued and grooved sheathing. The spaces between the studs are then filled with regranulated cork, and a waterproof protective lining applied over the sheathing. In either case a standard cold storage door is used to provide entry for icing.

The piping in Fig. 1 shows one method of providing automatic control of the water temperature. A thermostat is installed in the water line to the washer, which operates a valve on the drain line between the washer and the cooler sprays. As the water temperature decreases the valve closes, restricting the flow to the cooler sprays. This results in a higher level in the washer pan, which ultimately overflows into the second line which leads directly to the pump suction, or to the sump or collecting pan in the water cooler. By this arrangement the water temperature is kept uniform through a wide loading range within the capacity of the apparatus. An important item is the cooler overflow which should be located so that the water level in the cooler is kept slightly below the bottom of the ice blocks. No makeup water is needed for this system as the ice meltage far exceeds any evaporation that may occur, so that when the system is operating there is a constant flow of water from this source to the sewer.

Most designers desire a system in which the water rejected is at a high temperature; this may be accomplished with this piping arrangement by means of the float valve and drain shown in Fig. 4. The warm water returning from the air washer to the collecting pan passes through the float valve. When the water level in the pan passes the most desirable point the float valve closes, and the relatively warm water from the washer is discharged to the sewer.

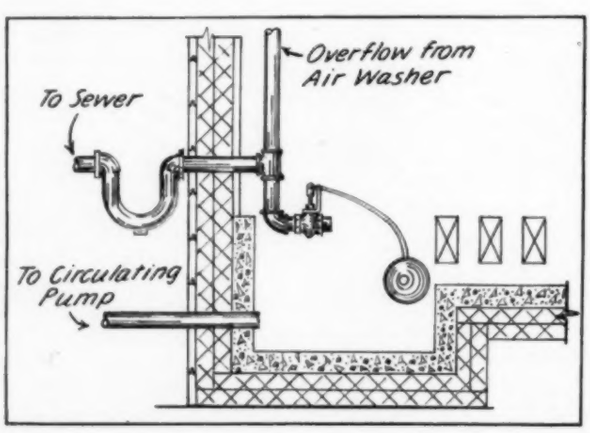


FIG. 4—DETAIL OF WATER COOLER

Piping Problems of the Bakery

—*Refrigeration Piping*

By Arthur W. Archer*

"Proper refrigeration is the most important factor in making a good quality of bread" seems to be the consensus of opinion among bakerymen. Not the least important factor in "proper refrigeration" is the piping. This article describes a well-arranged refrigeration piping system, and points out ways of securing satisfaction and economy in any system.

THE piping systems in a large wholesale bakery constitute a transportation system for fluids and gases upon which the plant depends for its continued production of bread. In this the bakery is typical of many other food manufacturing plants, such as cake, biscuit, and candy factories, but it has special problems with which the designer must be familiar if the piping is to function efficiently.

The various piping installations include those for refrigeration (with which this article will deal), water supply, heating and process steam, gas, and air.

Bakeries Largely Mechanized

The technical information in regard to piping arrangement and equipment has not progressed in accordance with the growth of the baking industry. Various inventions and new equipment have been tried out or proved in the bakery plants under actual working conditions. Necessary revisions and makeshifts in many instances have been made in the equipment and building to permit the expansion of this experimental field. This experimenting has reached a point where the new equipment has been accepted as a standard for bread manufacture, and it is now possible to consider the arrangement of the piping in connection with the equipment in a reasonably definite manner.

The various systems of piping can be arranged in a new plant, allowing head room or necessary clearance, so that they will prevent undue interference in the various lines and allow repairs and extensions without complications and interference with other lines or additional equipment.

While the baking process itself is not changed radically from the methods used for a great many years in the past, the amount of machinery used has increased very rapidly, and has reached the point where it is possible now to equip a bakery so that practically all of the work is done by machinery. This has correspondingly reduced the hand work.

A Typical Plant

A brief description of a medium size plant of one of the larger baking companies, together with an outline of the bread making process, is given here before taking up refrigeration piping in detail. The bakery has a relatively large ground area, being 132 ft. 0 in. by 136 ft. 0 in. with two full stories and basement under the entire building. The mixing room is in a third story over only a portion of the ground area. The flour is delivered to the basement and stored for a definite length of time, after which it is blended and sifted, and conveyed by a mechanical apparatus to the mixers which are on the top floor. This flour, with various other ingredients, is converted by the mixers into either a sponge and dough or straight dough, properly fermented, and then dumped into the make-up machinery on the second floor, where it is processed and moulded into loaves which are panned, final proofed, placed in the oven, baked, and allowed to cool sufficiently for wrapping, and then delivered by truck to the trade.

Uses of Refrigeration in a Bakery

Refrigeration is required in the present-day bakery to secure the following conditions:

(1) Provide cold water.
(2) Maintain definite temperature in the fermentation room.
(3) Maintain preservative temperatures in cold storage room and yeast box with possible future use or extensions to bread cooling and controlling temperatures of other materials in storage.
(4) Conditioning air.

Direct-Expansion System Used

Careful consideration was given to the selection of the system to be used, and to the location of the engine or compressor room, because these two factors determine to a great measure the success of the plant, in that the first aids in obtaining economical operation

*Archer and Radotinsky, Architects, Kansas City, Mo.

and the second leads to economical installation cost, as well as low maintenance cost.

A direct-expansion system was used in this instance, first because the average climate was comparatively mild, and second, because this particular plant was confined to bread baking only. The latter results in a load on the refrigeration plant that is not especially heavy and is only periodical, for after the doughs have been run, although plant operation is continued for several hours, there is little or no use for additional refrigeration.

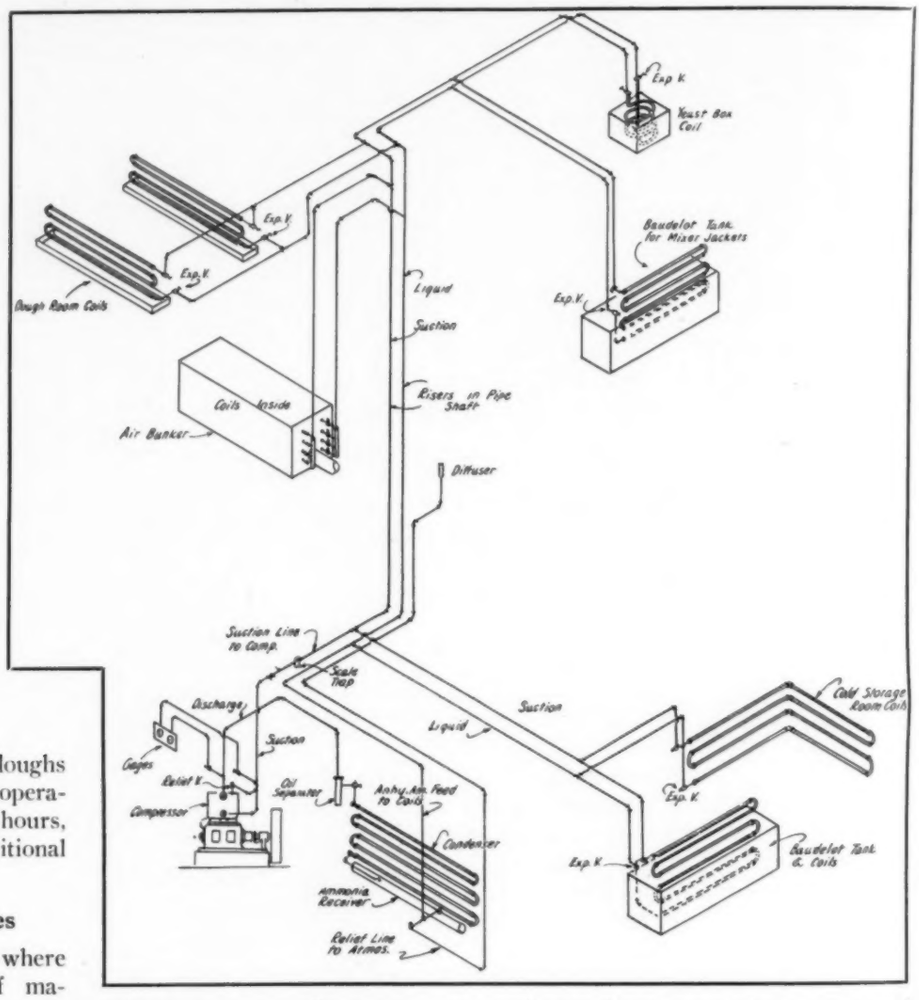


FIG. 1—A WELL-ARRANGED REFRIGERATION PIPING SYSTEM FOR A MODERN BAKERY

Brine for Severe Climates

In a great many plants where there is a definite storage of material other than that required for the bakery proper and where the climate is rather severe, that is, hot during the summer months and a continuous load is placed upon the refrigeration equipment, it is considered advisable to use brine, because of the hold-over possibility, in that brine can be circulated regularly and temperature maintained without actual operation of the refrigeration machinery.

It seems to be the consensus of opinion among well-informed bakery men that "proper refrigeration is the most important factor in making a good quality of bread." That being true, it behooves the designer and installation contractor to give careful thought to the system.

The Refrigeration Equipment

The refrigeration equipment in a room especially designed to receive it is the heart of the system. From this room the liquid and suction lines reach out to each point of refrigeration application, as shown in Fig. 1. The equipment room in the plant being described is 20 ft. 0 in. by 32 ft. 0 in. with an 11-ft. clear ceiling. The tubular condenser along the wall is connected through an oil separator to the compressors by an ammonia discharge line. A suction line extends from the compressor to the direct-expansion coils in the adjoining cold storage room; to the baudelot tanks, one located in the cold storage room and the other in the ingredient room adjoining the mixing platform; to the direct expansion coils in the fermentation room; and to the yeast box, as is shown in Fig. 1.

It was considered advisable to use a twin setting of compressors of 50 per cent each of the total load. This permits the operation of one of the compressors during the milder portion of the season, and in event of a breakdown, a definite portion of the work, at least, can be carried on without undue interference with the plant, and in some cases by careful manipulation the plant can operate until repairs have been made to the other compressor or system.

It is considered advisable to increase the calculated theoretical compressor capacity by about 30 per cent to provide for longer mixing time or increase in production and to compensate for greater radiation when the outside temperature rises considerably above 100 degrees.

Pipe Shaft Provided

In this plant a pipe shaft was provided adjacent to the elevator shaft, and made sufficiently large that all pipes used for the main distribution of all systems could

be installed through this shaft, so that they would be concealed yet accessible, and protected from the hard usage and abuse that is often encountered around plants of this description.

It is also found that considerable saving in the length of such lines is accomplished by a practical arrangement of the various departments adjacent to this main distribution system in such a manner as to reduce all lines without, of course, interfering with the proper correlation of the various departments.

Provisions for Cleaning Must Be Made

At all stages of the design and actual installation of the piping, the sanitary requirements of a modern food manufacturing business were provided for. These included the location of coils so they could be easily reached for cleaning and painting, and the location of hot water cocks in order that all coils, especially those over the baudelot tanks, could be washed down.

Cooling and Heating the Mixing Room

In this plant the mixing and fermentation occurs in the same room on the third floor, the fermentation portion having a 13-ft. ceiling, while the ceiling of the half where the mixers are located is 20 ft. high. Heating is accomplished by unit heaters thermostatically controlled, humidity effected by four disk humidifiers, and the necessary cooling to maintain a temperature of 80 F in summer furnished by direct-expansion coils. The latter consist of two coils five pipe high, each coil containing sufficient lineal feet of 2-in. pipe to secure the desired temperature. These coils are suspended from the roof steel on bar hangers with bolt and pipe supports, as shown in Fig. 2. The pipes in each coil are spaced 8 in. vertically and 12 in. horizontally. The two coils are located at the third points of the fermentation part of the room to afford even distribution.

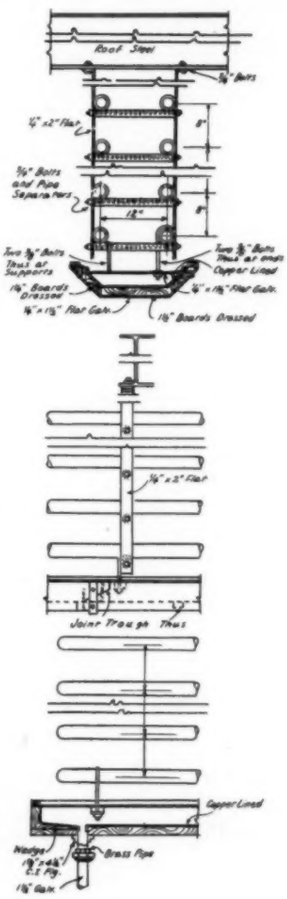


FIG. 2—DETAILS OF MIXING ROOM COILS

As a certain amount of moisture will condense on the coils, drip troughs were suspended just below the coils and connected to the drainage system through a funnel or indirect fitting. These troughs were constructed of wood lined with copper, and pitched slightly to drain. The detail of the coil and trough is shown in Fig. 2.

Baudelot Tank in Storage Room Saves Money

Considerable saving was effected by placing the larger of the two baudelot tanks in the cold storage room, eliminating the necessity of insulating the tank and reducing the amount of direct-expansion piping in the room necessary to hold the temperature at 40 F. Although ceiling location of coils in a cold storage room in a bakery is preferable where sufficient head room is available the coils in this plant were hung at the side walls as structural considerations afforded a ceiling height of only 9 ft. 6 in. The coil, which was installed around three sides of the cold storage room, the baudelot tank occupying most of the fourth side, consists of a single tier, six pipe high, of 2-in. pipe. The pipe is fastened at 8-in. centers with ⅜-in. U-bolts to angle hangers which are suspended from the ceiling and braced to the wall at their lower end. A drip trough, similar to those in the fermentation room, is fastened rigidly under the coil. The pipe was located 8 in. from the wall, and care was taken to keep the whole assembly of pipe and trough sufficiently high above the floor so as not to interfere with barrels of milk and malt stored next to the wall. Fig. 3 shows the arrangement of the pipes and trough.

Storage Box for Yeast

The cold storage box for yeast is simply a refrigerator about four feet square and ten feet high containing trays for the loose storage of pound cakes of yeast. In the top of the box is a circular coil of 1¼-in. pipe at 3-in. centers in a small brine tank so that the temperature of 40 F will be maintained when the compressor is not in operation. A ⅜-in. liquid line feeds this coil, and a ¾-in. suction line connects to the 1¼-in. line at the fermentation coils.

Construction of the Cooling Tank

As noted above, the baudelot cooling tank for ingredient water at 34 F for doughs is located in the cold storage room. This tank is constructed of ¼-in. galvanized steel with welded joints which were flushed with tin solder to prevent possible rusting. It is 18 ft. 6 in. long, 4 ft. 8 in. wide, and 2 ft. 6 in. high, with a

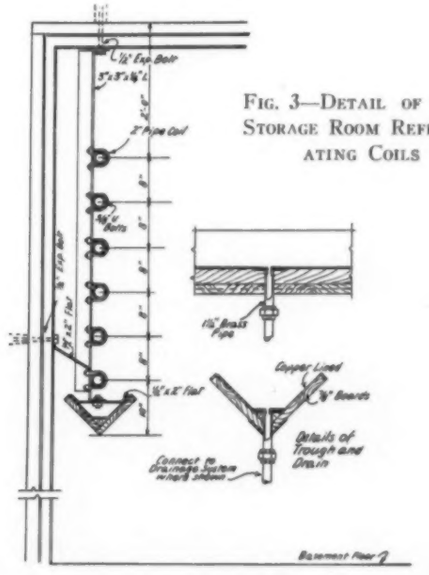


FIG. 3—DETAIL OF COLD STORAGE ROOM REFRIGERATING COILS

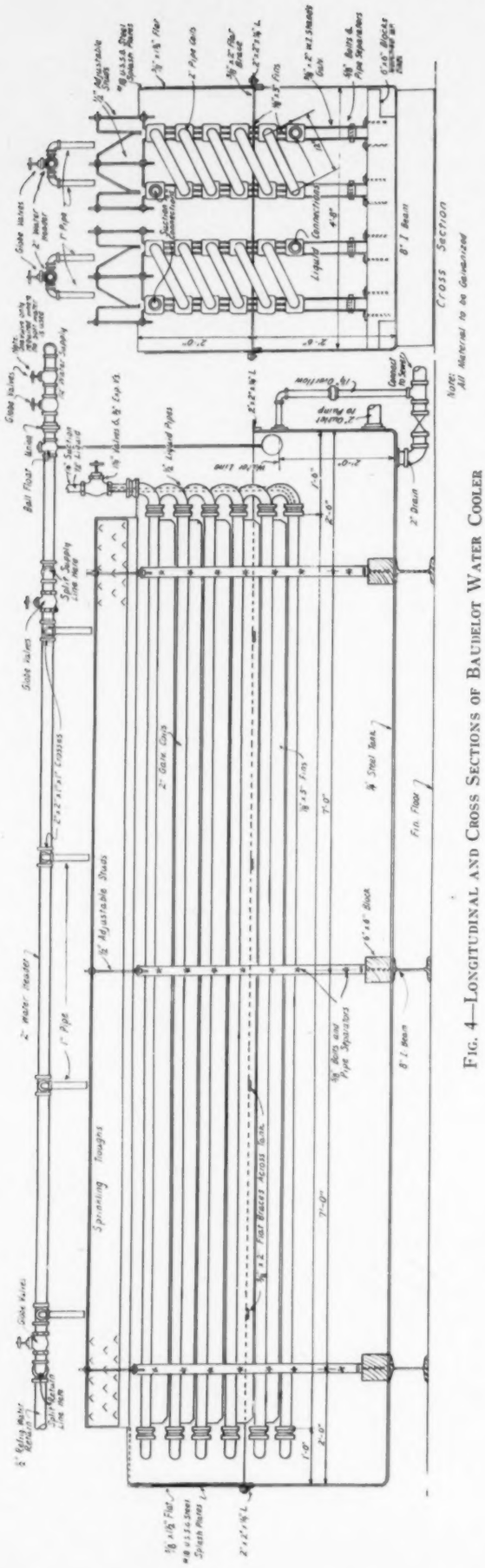


FIG. 4—LONGITUDINAL AND CROSS SECTIONS OF BAUDELOT WATER COOLER

storage capacity of twice the average hourly demand for ingredient water. The tank is supported on three 8-in. I-beams, and a splash plate of 18-gage steel adds two feet to its height. This tank also provides ice water for drinking purposes which is circulated by a small pump to drinking fountains throughout the plant.

The width of the tank makes the use of two coils feasible, thus providing flexibility to the system, and allowing one coil to be cut out when reduced production in the plant makes the full capacity of the tank unnecessary. Each double coil is six pipes high and is supported on heavy galvanized wrought iron standards so that all except one pipe is above the water line. A ball float valve in the supply line keeps the water level constant and a pump circulates the water to the measuring units at the mixers. Each tier of 2-in. pipes over which the water drips from the sprinkler troughs above is fourteen feet long. The pipes are spaced 12 in. horizontally and 6 in. vertically. The ammonia liquid enters at the lowest point of the coil. To direct the flow of water from pipe to pipe a $\frac{1}{8}$-in. metal fin is welded to the underside of each pipe for its full length. Fig. 4 shows the general construction of the tank and coils.

Separate Tank for Mixer Jacket Water

A separate baudelot tank is used for the 34-F water to be circulated through the mixer jackets. This tank is located in the ingredient room near the mixing platform and is insulated with 2-in. cork around all sides and the bottom. The entire tank is enclosed in a wooden box made of 1-in. tongue and groove boards, with a hinged cover to facilitate cleaning. The tank is of metal construction similar to the other tank but is 10 ft. 0 in. long, 2 ft. 4 in. wide, and four feet high, with a storage capacity of 350 gallons. Twenty-five gallons per minute is the maximum required to be circulated through a jacket. The one double coil is supported from blocks in the bottom of the tank so that half the coil is submerged, thus tending to hold the water at the desired temperature when the pump is not operating. The load on this coil is not great as the temperature of the water returning from the jackets is raised only four to six degrees. The pipes are spaced 12 in. horizontally and 4 in. vertically. The method of distributing the water over the coil is similar to that employed in the other tank. (See Fig. 5.)

Cold Air for Mixer Bowls

Many bakers prefer to have cold air supplied to the mixer bowls to reduce the temperature of the dough, as well as to whiten or produce a better color in the finished loaf. Air bunkers as shown in Fig. 6 are located as close as possible to the mixers so as to reduce the temperature increase to the minimum. Air admitted to the bowl of the mixer should be about 32 F; lower temperature usually causes sweating. Bunkers should be properly housed in, and located on the roof. Air intakes should be arranged to receive the supply from exterior or interior of the building as conditions may require.

Bread coolers are usually suspended on the ceiling under the traveling oven. During the summer months it is sometimes necessary to supply conditioned air to cool the bread properly in reasonable time. Many companies are now manufacturing excellent units for sup-

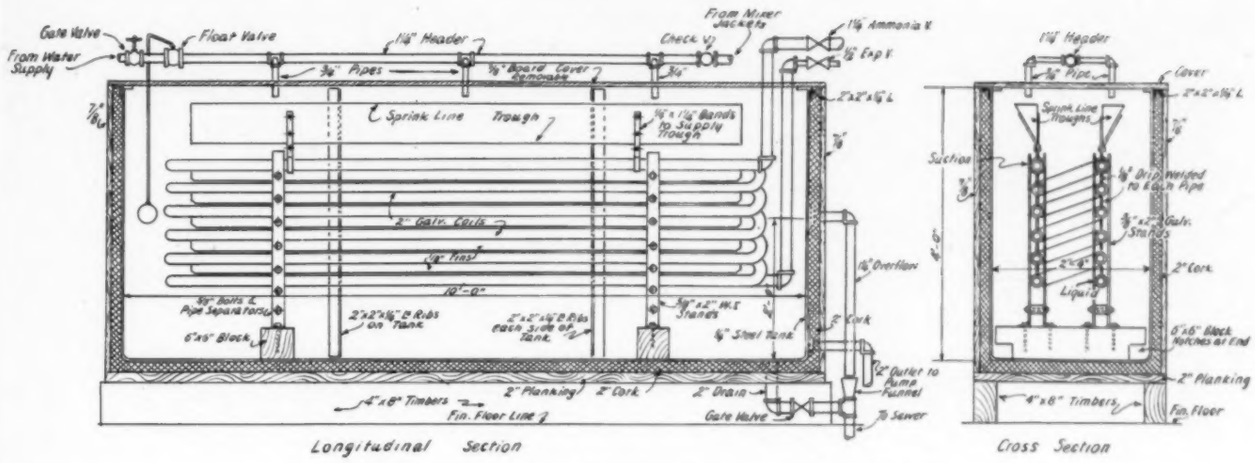


FIG. 5—DETAILS OF SMALL BAUDELOT TANK FOR MIXER JACKETS

plying air for all phases of bakery work. As this paper is setting forth the piping arrangements of bakery work such equipment is not mentioned in detail.

Cooling Tower Saves Water

In this particular locality the cost of water is a considerable item in the cost of plant operation. A standard cooling tower is installed on the roof, and all condenser water is circulated rather than wasted to the sewer. All nozzles are piped and valved to drain to prevent freezing during winter weather.

The Pipe and Fittings

The size of most of the pipe used has either been stated or is shown in the illustrations. It is quite essential that all pipe should be large enough to reduce friction to the economic minimum. In common with many other food factories, the bakery business is one of continual expansion in which larger pipe sizes more than justify the small additional cost.

All pipe used for the ammonia system was standard steel, full weight, and is giving quite satisfactory service. Pipe galvanized on the outside was used for the coils in the fermentation room, as well as the baudelot coils.

All fittings, such as tees, ells, flanges, valves, and return bends were of a heavy cast iron or drop forge steel. Return bends were used for all coils where the bend was less than ten inches on center. These were tongue and groove open pattern return bends with square flanges. All connections to coils, and all joints in the ammonia system, were made with square flanged fittings. Pipe was used in as long pieces as possible in order to obtain the least number of joints.

Coils having bends of ten inches or more on centers were made continuous by bending standard 20-ft. lengths of pipe and welding the joints.

Expansion valves were installed on the liquid lines in front of each direct-expansion coil, and ammonia valves on the suction lines leaving the coil, so that each individual coil can be cut out independently without interfering with the balance of the system.

Careful Insulation an Aid to Economy

The insulation of pipes carrying refrigerants in a bakery presents no special problems, although there are a few points well worth consideration. All lines of the ammonia suction system, including the valves and fittings, throughout the entire plant, were insulated with standard brine cork covering having a mineral rubber finish. This included the lines in the cold storage room except where such lines were directly over drip troughs. Valves and fittings were covered with moulded cork, all space between cork and body of fittings being filled with paraffin wax. The covering was extended through floors, walls, and hanger rings to provide a continuous insulation. Although in general the liquid lines were not covered, those in the fermentation room were insulated with ice-water thickness cork to eliminate the drip from the condensation which would collect on these pipes.

Arrangement Should Allow for Expansion

The piping for refrigeration systems for plants for food production should be so arranged that all surfaces may be readily cleaned, removed or repaired with the greatest ease. Fittings for future connections or extensions, if judiciously placed, are insurance against excessive improvement costs later. The designer should keep ease of supervision, accessibility for cleaning and simplicity of operation constantly before him as important factors in the successful operation of refrigeration installations for plants producing food products.

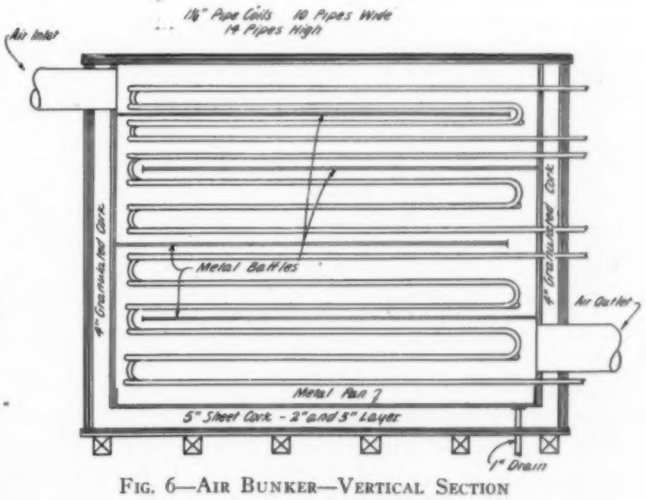


FIG. 6—AIR BUNKER—VERTICAL SECTION

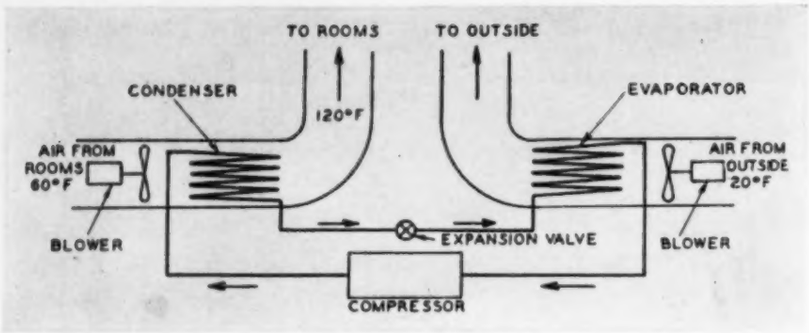


FIG. 1—SKETCH OF AN INVERTED-REFRIGERATION PLANT FOR AIR CONDITIONING

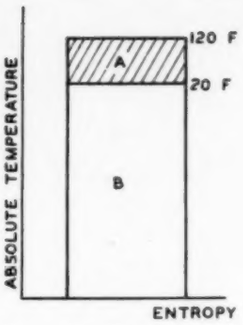


FIG. 2—TEMPERATURE-ENTROPY DIAGRAM FOR THE CARNOT CYCLE

Improved Inverted-Refrigeration Cycle for Summer-and-Winter Air Conditioning

By H. J. Stoever*

USE of the refrigeration cycle for air conditioning in both winter and summer has attracted considerable attention during the last few years. These so-called "inverted-refrigeration" plants may be entirely automatic and clean, and may eliminate the need of fuel-storage space. Although both initial and operating cost may be considerably higher than for the more conventional type air-conditioning plants with low-priced fuels, there are districts where reversed-refrigeration is commercially practicable. The operating cost of an "inverted-refrigeration" installation depends to a large extent on the available electric power rate and on the performance of the plant. Moreover, the performance of the plant is greatly influenced by the thermodynamic cycle of operations for which it is designed so that any changes in this cycle will be reflected in the operating cost.

Certain possibilities of improving the thermodynamic cycle of operations are recognized, but in every case the advantage to be gained is limited by certain inherent characteristics of the system. It is shown in the following discussion that the Carnot cycle, operating as it does between two fixed temperatures, is not the most efficient cycle for an inverted-refrigeration plant.

Operation of a Carnot-cycle Plant

Fig. 1 represents diagrammatically the operation of a plant operating on the vapor compression cycle; modifications of this arrangement are confined for the most part to the manner of transferring heat from the condenser to the air of the room, but these changes do not affect the thermodynamic cycle. The operation of the plant is the same as that of the ordinary refrigerating plant. The vapor coming from the evaporator is compressed and thereby has its temperature raised. The pressure in the condenser is maintained high enough that condensation takes place at a temperature above room temperature, and so the heat dissipated flows into the air being circulated through the conditioned space. The liquid refrigerant resulting from this condensation is then reduced in pressure by passing through the expansion valve and is returned to the evaporator. A sufficiently low pressure is maintained there by the compressor so that the refrigerant boils at a temperature below the outside air temperature. Heat flows from the outside air to the refrigerant, and the vapor formed is again drawn off by the compressor, and the cycle is repeated.

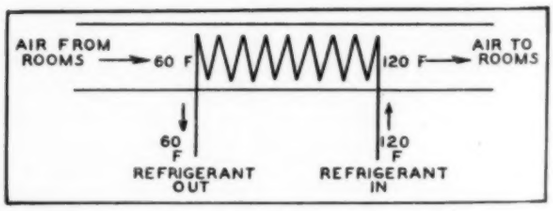


FIG. 3—COUNTER-FLOW HEAT INTERCHANGER

* Thermodynamic engineer, Research Laboratories, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

Performance Measured by Coefficient

The performance of an inverted-refrigeration plant is measured by a quantity called the *coefficient of performance* and defined as the ratio of the total heat supplied to the building divided by the heat equivalent of the electrical energy consumed by the plant. For example, if the coefficient of performance is equal to 5, then 5 kw-hr. of heat are supplied to the building for every one kw-hr. of electrical energy consumed. This apparently absurd performance is explained, of course, by the fact that 4 kw-hr. of heat flow from the outside air to the refrigerant in the evaporator. A graphical interpretation of this coefficient is very useful and can be obtained by plotting the cycle on the temperature-entropy plane.

Fig. 2 shows an ideal Carnot cycle. The shaded area A represents the heat equivalent of the electrical energy consumed, area B represents the heat supplied to the system by the outside air, and the total area $(A + B)$ represents the heat rejected by the system to the building. The coefficient of performance, then, is the ratio of the total area $(A + B)$ to the shaded area A. Assuming the outdoor air temperature to be 20 F and the air being circulated from the building to be heated to 120 F, the value of this coefficient for the ideal case shown is 5.8.

Performance of so-called "inverted refrigeration" air-conditioning plants is greatly influenced by the thermodynamic cycle of operations. In this article, an improved inverted-refrigeration cycle is discussed, and methods of approaching it in actual practice are described and illustrated.

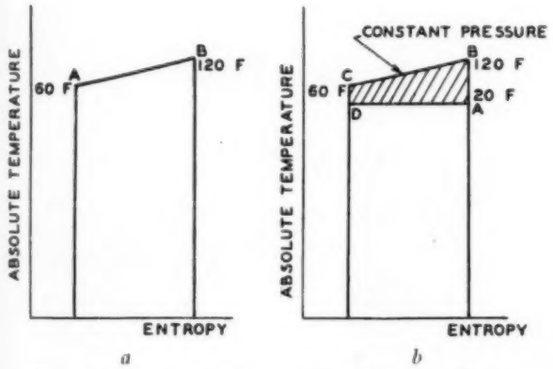


FIG. 4—THE IDEAL INVERTED-REFRIGERATION CYCLE

Performance of Actual Plant Different from Ideal

The performance of an *actual plant* is not as good as that of an *ideal plant* operating between the same temperature limits for several reasons. In order for heat to flow from the outside air at 20 F to the refrigerant within the coils, the refrigerant must be at a temperature lower than 20 F. Similarly, the refrigerant in the condenser must be at some temperature higher than 120 F if the air is to be heated to this desired temperature. It is evident that the coefficient of performance is decreased by these changes since the shaded area in Fig. 2 is increased. Beside the necessity of temperature gradients, neither the compression nor the expansion takes place in the frictionless, adiabatic manner assumed in Fig. 2. The fact that the vapor is superheated on being compressed further reduces the coefficient of performance. Finally, the inefficiencies of the compressor and of the motor must be considered, so that the coefficient for an actual plant operating between the temperatures assumed would probably be, say, 2.4.

A Cycle Which Improves the Ideal Coefficient

The compression cycle tends to approach the performance of the Carnot cycle; it is not true, however, that the Carnot cycle is the most efficient cycle for the conditions which exist in the inverted-refrigeration plant. Including the air to be heated as part of the system, the plant is not reversible in the thermodynamic sense if the refrigerant follows the Carnot cycle. There is, however, a cycle that the refrigerant may follow which will produce a reversible system and thereby considerably increase the *ideal* coefficient of performance of the plant. Thus, referring again to Fig. 1, and considering the fact that cool air circulated from the building is probably at a temperature of about 60 F and is to be heated to 120 F, it is evident that a supply of heat at 120 F is not necessary to heat the air from 60 to, say, 70 F. A much lower condenser temperature on the side where the cool air enters would be just as satisfactory, and so, assuming no temperature gradients, an ideal arrangement is the coun-

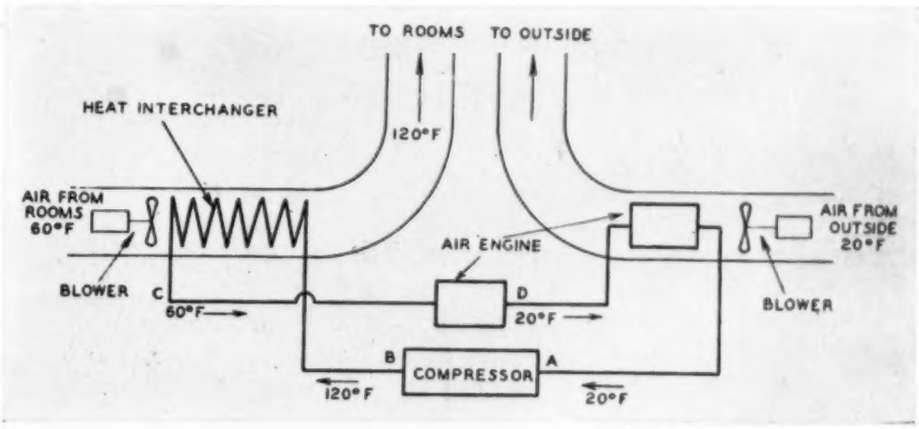


FIG. 5 — DIAGRAMMATIC SKETCH OF AN IDEAL INVERTED-REFRIGERATION PLANT

ter-flow system shown in Fig. 3, in which the refrigerant enters the coils at 120 F and leaves at 60 F and is always at the same temperature as the air in contact with it.

When the air being circulated is heated from 60 F to 120 F, it changes in state as shown in Fig. 4*a*. The area

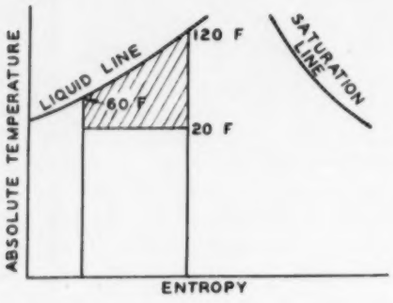


FIG. 6—IDEAL CYCLE USING VAPOR AS THE REFRIGERANT

under the constant pressure curve *A-B* represents the heat added to the air. Logically, the ideal inverted-refrigeration cycle must be one whose total area coincides exactly with the area of Fig. 4*a*; such a cycle is shown in Fig. 4*b*. Assuming that air is used as the refrigerant, *A-B* represents a frictionless, adiabatic compression, *B-C* the cooling of the refrigerant at constant pressure while passing through the heat-interchanger, *C-D* a frictionless, adiabatic expansion down to the outdoor temperature, and *D-A* a frictionless, isothermal expansion back to the original state *A*. In order to have an isothermal expansion, it is necessary that heat be supplied to the air as it expands; and since this expansion takes place at the outdoor air temperature, the necessary amount of heat can be supplied by the outdoor air.

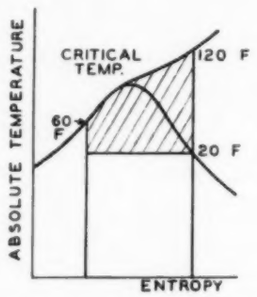


FIG. 7 — A CARBON DIOXIDE CYCLE

The manner in which such a cycle might operate is shown in Fig. 5. The air is compressed from 20 F at *A* to 120 F at *B*. It then passes through the heat-interchanger and cools at constant pressure from 120 down to 60 F while it is heating the air being circulated from the building from 60 to 120 F. It is then expanded adiabatically down to 20 F at *D* where its pressure is at some intermediate value. Finally, it is expanded at a constant temperature of 20 F from *D* back to *A*. In order to maintain this constant temperature, the cylinder of the engine might conceivably be placed in contact with the outdoor air so that heat could flow from the outdoor air to the refrigerant. Since the two air engines and the compressor can be connected together in some way, the amount of power required to drive the plant is equal to the difference between the power required to drive the compressor and the power that is obtained from the engines.

The Cycle's Coefficient of Performance

Numerically, this cycle has a coefficient of performance equal to 8.0 for the assumed conditions as compared to 5.8 for the Carnot cycle operating between the same maximum temperature limits. However, the cycle as described would be difficult to follow in actual practice. A fairly satisfactory approach to all of the processes required might be realized with the exception of the isothermal expansion. Even with an elaborate mechanism, it is doubtful whether or not a sufficiently high rate of heat transfer could be realized to make this process reasonably efficient. There are various other schemes, however, which may be used to arrive at approximately the same result given by this ideal air cycle.

Theoretical Result Obtained with Vapor Cycle

The same theoretical result is obtained from the vapor cycle shown in Fig. 6, providing that the specific heat

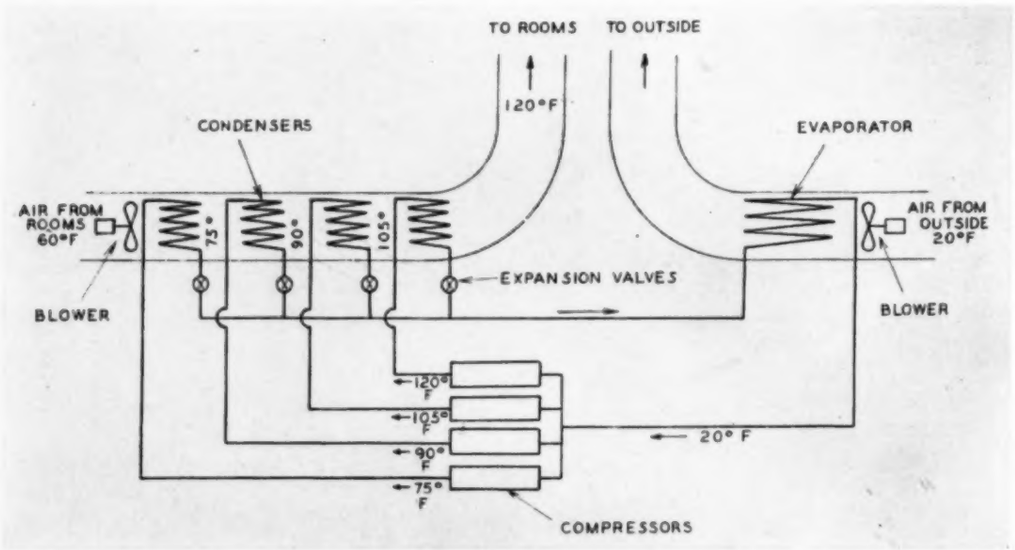


FIG. 8—DIAGRAMMATIC SKETCH OF CYCLE USING FOUR CONDENSERS

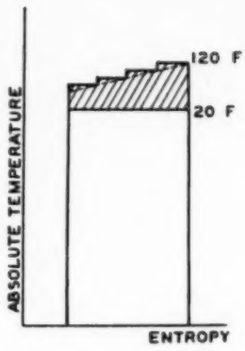


FIG. 9—TEMPERATURE-ENTROPY DIAGRAM FOR CYCLE USING FOUR CONDENSERS

of the liquid refrigerant is constant. The cycle is the ordinary compression-type cycle except that the compressor instead of being supplied with saturated vapor is supplied with a mixture of the liquid and the vapor such that only liquid is discharged. Assuming the same conditions as before, this liquid initially at a temperature of 120 F cools down to 60 F and thereby heats the air circulated from the building. Whereas the isothermal expansion offers no difficulties, the unusual compression required is the obstacle in the way of realizing this ideal cycle.

A Method of Approximating the Cycle

A fairly close approximation to the ideal cycle can be realized by using the cycle shown in Fig. 7. Some refrigerant (such as CO_2) having a critical temperature below 120 F is required. The cycle is the ordinary CO_2 refrigeration cycle, but the desired result is accomplished since the refrigerant does not condense at a constant temperature but, instead, gradually cools down. It is evident from Fig. 7 that this cycle has a coefficient between that of the ideal cycle in Figs. 6 or 4*b* and that of the Carnot cycle. The cycle is practicable though the high pressures might prove troublesome in some cases.

An Approach to Cycle Shown in Fig. 8

A practicable approach to the ideal cycle is that shown in Fig. 8. This arrangement is similar to the plant shown in Fig. 1 except that two or more condensers at successively higher temperatures are used instead of a single condenser. Each condenser must have a separate compressor, or possibly a single compressor equipped with some sort of distributing device might be used, which would be so designed that the compressor would discharge successively into each of the condensers. It would also be possible to use a properly designed multi-stage compressor in which each stage discharged into a separate condenser. The resulting cycle is shown in Fig. 9 and consists simply of as many separate Carnot cycles as there are condensers. The cycle approaches nearer and nearer to the ideal cycle of Fig. 4*b* as the number of condensers is increased, but it would probably be true that most of the advantage could be gained by no more than three or four stages. The theoretical coefficient of performance for the plant using four condensers as shown and operating under the same conditions of temperature as before is about 7.2 as compared to 8.0 for the ideal cycle.

Conclusions

The exact amount of the improvement varies with the conditions under which the plant operates and under some conditions may not be enough to justify the increased initial cost. Regardless of the *practical* improvement which may result, however, the fact that the Carnot cycle, operating as it does between two fixed temperatures, is not the *ideal* cycle for the inverted-refrigeration plant and that an improvement is *theoretically possible* should be recognized by air-conditioning engineers.

Reversed-Refrigeration Cycle Heats Office Building

AN OUTSTANDING installation for heating a building by means of a reversed-refrigeration cycle is that in the office building of the Southern California Edison Company at Los Angeles, which rises over 200 ft. above the sidewalk, has 13 main floors, and is one of the first all-electric buildings in history. The building has a content of 3,778,000 cu. ft. and its gross floor area is 269,000 sq. ft.

The mechanical equipment is installed partly in the basement and partly in the tower

on top of the building; this enlarged pent house includes a cooling tower through which the air is forced by means of fans. When the air once in a long while gets so cold that there is danger of freezing the water in the sprays, the refrigerating machinery is shut down, and direct electric heating is depended upon entirely. Methyl chloride is circulated by four compressors, each having a capacity of 120 tons and each driven by a 200-hp. synchronous motor. In summer the system is used for cooling, which requires only about three-fourths the capacity of the plant. Large fans, some in the basement and some in the roof tower, distribute the heat.

By Clyde R. Hoey Jr.*

Piping a Blow-Down Which Saves $

The piping for a continous blow-down system which has shown a heat saving amounting to over $11.00 a day is described here; features are simplicity in operation and metering of the blow-down.

NO ATTEMPT is made in this article to discuss the advantages or disadvantages of the continuous blow-down system, but the purpose is to describe the piping, construction and operation of a system together with the saving of $11.64 per day which has resulted from its use. The blow-down system as designed and constructed for the two boilers of our plant (each boiler is capable of generating 300,000 lb. of process steam per hr. at 400-lb. gage pressure and 700 F) consists essentially of the blow-down collectors, a flash tank, a surge tank, a flow meter, and the necessary piping and valves as shown in Fig. 1.

Location of Collectors

The collectors are located in each end of the boiler drum containing the most concentrated water; they were originally installed as skimmers but were discontinued in this capacity and later used as collectors when this system was installed. The only change made in them was to depress them about 3 or 4 in. below the water level in the drum and turn them so that they would receive the most concentrated water coming from the circulating tubes. The pipe from each collector passes through the end of the drum to a gate valve and these two lines are joined in a common line before reaching the regulating valves at the flash tank.

Two Regulating Valves for Each Boiler

There are two regulating valves for each boiler, one of which is a 2-in. valve, which is the size of the pipe from the collectors. This valve is used when the river water has been heavily treated with chemicals to make it suitable for boiler feedwater, which naturally requires a larger percentage of blowing down. The other valve is ¾-in. arranged as a by-pass around the larger one. The smaller valve is used most of the time since it is little subject to cutting of the seats because of the wide opening for a given amount of discharge.

The lines from these valves discharge into a flash tank which consists of a steam separator 3 ft. in diameter by 7 ft. high having a baffle to throw the solid water downward and allow the flashed steam to pass out free of water. Any suitably baffled tank of sufficient size would serve the purpose.

Flashed Steam Piped to Feedwater Heater

The flashed steam is piped to a contact-type feedwater heater carrying 2 lb. gage pressure; since the connecting piping is short and of ample size, the pressure in the flash tank is practically 2 lb. Naturally any market for low pressure steam that is available could be used. However, the lower the pressure in the flash tank, the larger becomes the amount of the blow-down converted into steam.

The separated water passes out the bottom of the flash tank into a water seal of sufficient head to counteract the pressure in the flash tank. It was found necessary to make the seal much greater than that theoretically required, because of the more or less surging pressure in the heater and flash tank which blew out a seal over twice as great as theoretically required.

The water seal line discharges into the *top* of the surge tank to prevent siphoning the water in the surge tank back into the flash tank if a vacuum were created by the closing of all valves and the condensation of the steam in the tank. The surge tank

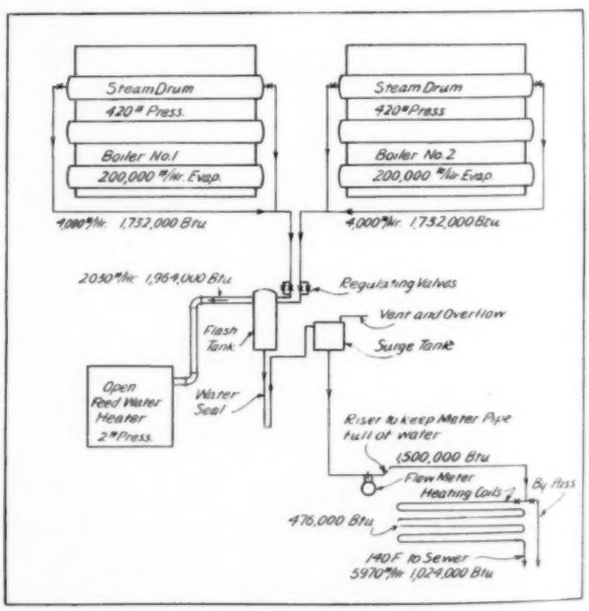


FIG. 1—SCHEMATIC LAYOUT SHOWING THE PIPING FOR THE CONTINUOUS BLOW-DOWN SYSTEM, THE USE OF WHICH RESULTS IN A SAVING OF ABOUT $11.00 PER DAY

* Heat engineer, The Champion Fibre Company, Canton, N. C.

es $11.64 Daily

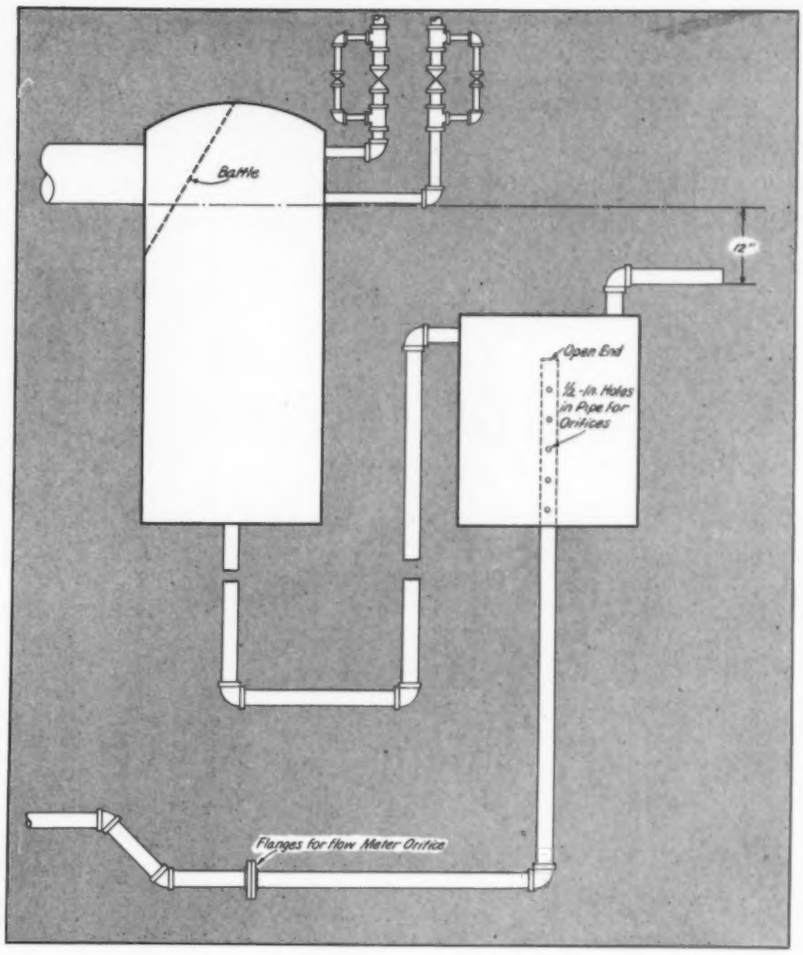


FIG. 2—DETAILS OF REGULATING VALVES, FLASH TANK, SURGE TANK, ETC.

has an atmospheric vent and overflow to take care of any siphoning action or closing off of the surge tank outlet. The overflow line from this tank should be at a somewhat lower elevation than the steam connection to the heater so that in case the pressure in the heater were lowered to zero gage, there would still be an overflow to the atmosphere to prevent water passing over into the heater.

As first constructed, the outlet from the surge tank was in the bottom, but because of the somewhat fluctuating pressure in the flash tank, the flow was so erratic as to make use of a flow meter impossible. This trouble was overcome by extending the outlet pipe up to within a few inches of the inlet pipe and leaving it open-ended. Several half-inch holes were drilled into this projecting pipe at equally spaced intervals which act as orifices for the discharge of water into the outlet pipe. This so dampened the fluctuations that the flow meter could make an intelligible record. A gage glass on this tank shows the depth of water in it and is useful as a rough check in setting the regulating valves. Details of the regulating valves, flash tank, surge tank, etc. are shown in Fig. 2.

The surge tank has sufficient elevation that the water can flow by gravity to a set of heating coils composed of old economizer sections piped in series. To insure having a full pipe of water for the orifice of the flow meter at all rates of flow, two 45-deg. elbows were used with a nipple between them to form a trap in the line. There is a suitable by-pass for the heating coils so that in summer the water from the surge tank may go directly to the sewer.

Flow Meter Aids in Setting Valves

The rate of blow-down required is regulated by hourly tests made to determine the concentration of the water in the boiler. The flow meter is valuable in setting the regulating valves since it shows immediately any change in the amount blown down. Experience—together with testing—has shown the operators about what the rate of blow-down should be for different conditions, and the hourly tests are the means of preventing the waste of too great a blow down or the danger of too great a concentration.

The Heat Saving Which Has Been Made

The heat saving is easily computed from the heat content of the water and steam at the various pressures and temperatures. Water leaving the drum contains 433.0 Btu per lb. as heat of the liquid. When this passes into the flash tank, where the pressure is lowered to 2 lb., it contains 187.5 Btu per lb., assuming no heat loss by radiation or other causes; the pipes to the flash tank and the flash tank itself are well covered so that this loss is very small. This pressure drop makes available 433.0—187.5 or 245.5 Btu per lb. for evaporating part of the blow-down into steam. The latent heat at 2 lb. being 965.4 Btu, the amount evaporated is $245.5 \div 965.4$ or 0.254 lb.; or 25.4 per cent of the water blown down is returned to the heater in the form of flashed steam. The percentage of heat saved by this flashing is $(245.5 \div 433.0) \times 100 = 59$ per cent. When each boiler is generating 200,000 lb. per hr. and the blow-down is 2 per cent (this blow-down being necessary because of the large amount of make-up water required for the feed water) the heat saved is $2 \times 200{,}000 \times 0.02 \times 245.5 = 1{,}964{,}000$ Btu per hr. At 20c per million Btu, this amounts to $0.39 per hr. or $9.36 per day. When the water leaving the surge tank is passed through the heating coils, it is cooled to 140 F before passing to the sewer. The heat of liquid at 140 F is 107.8 Btu per lb. The further saving in heat

is 187.5 — 107.8 = 79.7 Btu per lb. if the small loss caused by dropping the pressure from 2 lb. to atmospheric in the surge tank is neglected. Since 25.4 per cent of the initial blow-down is returned to the heater, only 74.6 per cent passes to the coils. Hence the heat saved in this way is $2 \times 200{,}000 \times 0.02 \times 0.746 \times 79.7 = 476{,}000$ Btu per hr. At 20c per million Btu, the saving is $0.095 per hr. or $2.28 per day. Hence the total heat saving during the period the heating coils are used is $11.64 per day, which is a good return on this investment.

We have found this system to be practically free from trouble; it is easily operated and gives satisfactory results.

• • • • • • •

Estimating Duct Work for *Louisiana State Capitol Building* Air-Conditioning System

. . . . Main Duct Which Supplies Conditioned Air to Memorial Hall and Adjacent Corridors; the Duct Is 25 Ft. Wide and 6 to 8 Ft. High

BECAUSE of the intricate details of the ventilating system of the new Louisiana state capitol building,* the ventilating contractors adopted a simplified and accurate method of interpreting the mechanical plans. Upon receiving blue-prints of the ventilating system, the contractors divided the entire system into individual units. Each unit was separately traced from the architect's plans. Each tracing consisted of the unit fan or fans and all the duct work connected with it, designating grilles, dampers, splitters, and all other mechanical devices related to the duct work.

Once the tracing was made, the duct work on the sheet was marked off into items, each item being an individual section of the duct work as it was to be fabricated in the shop. The items were numbered, as Item 1, Item 2, Item 3, and so on. The gage, size and length of each item was marked on the tracing, along with its number.

On one blank section of the tracing sheet a schedule was marked off. All items were transferred to this schedule and designated as: Item 1, its gage, size, length, weight per linear foot, and total weight per section as shown here. After each item had been scheduled in this manner, the total weights of each gage of metal used in the entire unit were determined by adding each column of weights marked on the schedule. This simplified the job of estimating material costs and insured accuracy.

*Consulting mechanical engineer, F. H. Chisholm; architects, Weiss, Dreyfous and Seiferth; ventilating contractor, Holzer Sheet Metal Works, Inc. Information supplied by Hugh W. Wright, The American Rolling Mill Co., Middletown, Ohio.

Estimating the Sheets Needed

Determination of the quantities of flat sheets of va-

Schedule Worked Out for Flat Sheets on Tracing of One Unit

Schedule No. 1—House of Representatives Unit

Item No.	Gage	Size of Duct Inches	Length of Duct in Feet	Weight per Linear Foot	Weight per Section per Gage					
					18	20	22	24	26	
1	18	120x18	32.0	54.97	1759					
2	26	18x14	4.0	4.90					20	
3	24	28x18	11.6	9.10				100		
					Total weights of each gage of sheet for entire unit					

Schedule for Angles and Inserts to Be Used in Erecting Duct Work on the Same Unit

Schedule No. 1—(Braces)

Item No.	Size Ls.	Weight per Linear Foot	Linear Feet	Total Weight	No. of Inserts
1	2x2	1.65	14	23	4
2	2x2	1.65	10	16.50	3
			Totals		

rious sizes required for the unit was accomplished by working out each item on the schedule sheet, designating the number and sizes of sheets required for each item on the tracing. As this was done in the contractor's office, much time was saved by shop mechanics while fabricating the duct work, and by carefully determining the sheet sizes for each item, waste of materials during fabrication was reduced to a minimum.

The method adopted to interpret the mechanical plans for the air conditioning and ventilating duct work for the new Louisiana State Capitol building provided a close working basis for the architect and contractor in visualizing the system, enabled an accurate preparation of the contractor's proposal from the plans, aided precision in interpreting the system and resulted in a saving of time in the manufacture and assembly of the ducts; it's described here.

An additional schedule was worked out for hanging and bracing all duct work. This specified the corresponding number of inserts, hangers, and angle iron braces required for each item scheduled, as well as the number of linear feet and the weight of the various angles. Over 150,000 lb. of galvanized sheet metal were used for the ducts and other parts of the system.

Thus, when the two schedules on each tracing were completed, the sheet metal contractors had an exact record of all materials required for the unit: sizes, lengths, gages, weights and quantities. The tracings and accompanying schedules served not only as the base from which the proposal could be made, but, when the contract was awarded, they proved valuable as shop details for the fabrication and erection of each unit of the ventilating system.

Conditioning System Described Briefly

The 33-story capitol building is situated in Baton Rouge; at its base it covers an area of over 45,000 sq. ft. and its height is 400 ft. A large memorial hall is on the first floor in the center of the building; the west wing branching off from this hall contains the senate chamber and the east wing is devoted to the house of representatives. A dining room, cafeteria and kitchen are in the basement. The remaining floors house officials and departments of the State of Louisiana and contain approximately 110 offices.

As certain ventilated sections of the structure are unoccupied at times, the air-conditioning system was designed in individual units. Each unit is equipped with air filters. Cleaning of the filters is automatic; when the fan of the unit is shut down the deceleration starts a motor which operates a washing and cleaning unit in the filter apparatus.

The 25th floor (which includes the judges' offices) is cooled by means of conditioned air forced over automatically-refrigerated coils. The dining room and cafeteria in the basement are cooled by unit coolers suspended above the ceiling and discharging to the rooms through a series of distributing ducts.

The exhaust system for the entire building is one unit. Air is pulled into unit ducts and from them to branch ducts that lead downward to the sub-basement, where all are joined in the main exhaust duct, approximately 6½ ft. high and 12½ ft. wide. Air is expelled from this main duct from a passage that runs under the long, sloping stairway that leads to the front entrance. All duct work was paneled. A deodorizing machine installed at the exit of the main exhaust duct eliminates unpleasant odors from the kitchens, toilets, dining room and cafeteria by means of electrically-produced ozone.

A system of mushroom exhausts was worked out to remove air from the senate chamber and the house of representatives. Rows of the mushroom exhausts run the length of the room and are concealed by the main-floor seats. Each mushroom has its individual duct which runs through the floor and joins a large duct. Exit grilles located along the base of the walls also remove air from these rooms.

Air is introduced to the senate chamber through a cove between ceiling and side wall, fronted by a decorative plastered grille. In the memorial hall and the house of representatives, wall space is utilized for distributing fresh air; long vertical grilles between the windows and extending from floor to ceiling (almost 40 ft.) introduce the air.

In an article published last month it was stated that the usual recommendations for the percentage to be added to total heat loss to care for heating up the materials in buildings heated intermittently are far inadequate, that the heating-up load cannot be ascertained with any degree of accuracy by allowing a percentage of the normal heat loss load, and that when sufficient capacity is provided to care for the heating-up load, there must be means for quick and positive temperature control. Tests to determine the rate at which various building materials absorb heat were described, and test results were shown. The importance of this article is discussed here.

"Open for Discussion"

JOHN M. ROBERTSON'S article on "Heating-Up Load for Buildings Heated Intermittently" published in the May issue,[1] contributes some vital information to the heating engineer. In our experience we have come across many church buildings, particularly, in which the heating engineer has figured the capacity of his plant, and particularly that part of it which handles the auditorium, according to the standard rules for estimating heat losses, only to find that for some reason or other his calculations did not result in a plant of sufficient capacity. This is true whether the engineer uses a steam plant, a gravity furnace or a fan system and it is not an uncommon thing, particularly in the South, for us to find an auditorium which requires firing for twenty-four hours in order to get the heat down to the floor.

Two Elements Involved

There are two elements involved in this. One is the lack of sufficient air movement so that the heat put into the room rises to the ceiling and the air has cooled before it ever gets back down to the floor.

The other, and the one which Mr. Robertson points out, is that the heat absorbed by the material in warming up a cold building runs in some cases to almost twice as much as the amount of heat that is lost to the outside atmosphere.

Great progress has been made in recent years in heating engineering in the matter of figuring definitely what capacity should go in and this matter of the capacity required for intermittently-heated buildings seems to be about the only thing that has been overlooked and is just beginning to attract general attention.

[1] See p. 340, HEATING, PIPING AND AIR CONDITIONING, May 1932.

In our early experience in heating churches, beginning over twenty-five years ago, we encountered these problems with insufficient knowledge as to what really caused the trouble. We attributed it first to lack of knowledge on our part as to the actual capacity of our plants; when we found that a certain sized furnace would not produce the results which we had expected, we lowered the rating of it.

Later in our practice, when we began making tests to determine just exactly what our capacities were, we found that our ratings almost uniformly were about 50 per cent of the amount of heat that the furnace would produce in actual practice. This rating served our purpose very well until we ran into the reinforced concrete church; then we found that our ratings still were not low enough and we began to study to see what was really at the base of the trouble.

An "Experience Article"

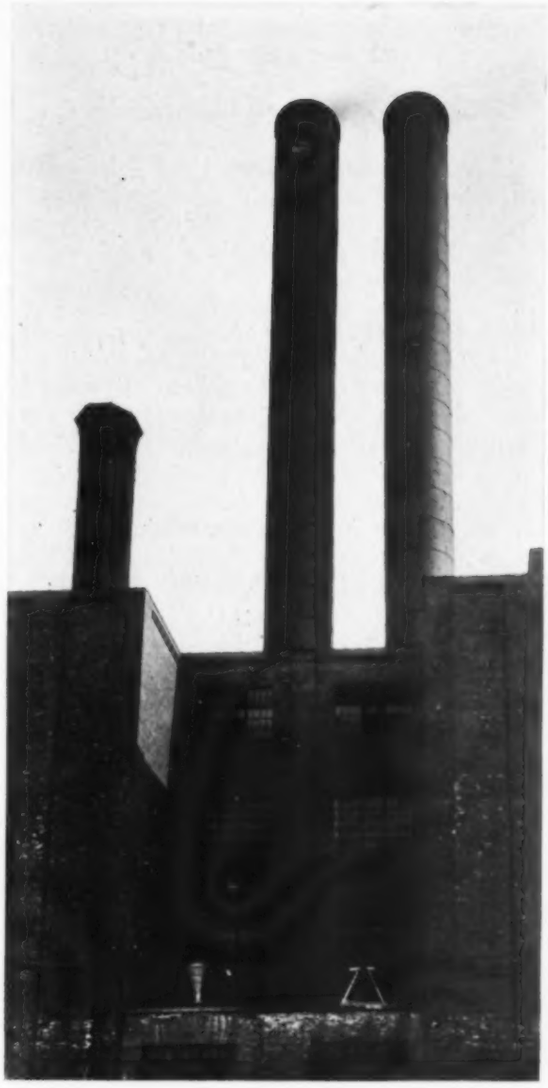
Mr. Robertson's article, therefore, is a culmination of study and experience that started many years ago. He has carried on personally and at a sacrifice of his own time, some experiments in order to get the actual figures shown graphically on page 342 of the May issue.

This information was published with the hope that others who are in the field of heating these buildings, which require heat only part of the time, may figure greater capacity and that those who enter the field only occasionally may have at their disposal the knowledge that will enable them to figure their plants correctly. It will mean freedom from trouble both for themselves and their clients; lack of knowledge along this line has gotten many churches into trouble.—*E. K. Campbell,* E. K. Campbell Heating Co., Kansas City, Mo.

By . . . . **William A. Hanley***

. . . Of importance to plants using large amounts of process steam is the arrangement between Eli Lilly and Company and the Indianapolis Power and Light Company whereby high-pressure steam is supplied the Lilly Co. by the utility through an underground line a mile long. The steam is used in turbines for generating current in the Lilly plant, the current being fed into the power company's lines, and the exhausted steam being used for process work and heating in the Lilly plant.

Mr. Hanley, director of engineering for Eli Lilly and Company, concludes here his explanation of the terms of the contract governing the arrangement.



THE KENTUCKY AVE. STATION OF THE INDIANAPOLIS POWER AND LIGHT COMPANY, FROM WHICH STEAM IS SUPPLIED ELI LILLY AND COMPANY

Plant and Utility Exchange Process Steam and Power

WHEN it became necessary to provide greater quantities of process steam and electricity for the manufacturing facilities of Eli Lilly and Company at Indianapolis, four possible schemes were considered as described in the May, 1932, HEATING, PIPING AND AIR CONDITIONING. After a careful study, an interchange of power with the Indianapolis Power and Light Company was agreed upon; a mile-long underground steam line supplies steam at 175 lb. with 100 F of superheat to the plant from the utility. The steam is used for generating electrical energy at the plant, which is fed into the power company's lines, and is then utilized for process work and heating. The Lilly Company takes its power from the utility's lines, and pays for it and for the steam; the power company pays the Lilly Company for the electrical energy generated by the Lilly turbines and fed to the power company's lines.

With the plan adopted for providing Eli Lilly and Company with steam and electricity, it is anticipated that a saving of $70,000 will be made by the Lilly Company during the ten-year period over other arrangements considered; a careful study of the possible arrangements is essential, of course, in any case and several plans for meeting the requirements were analyzed thoroughly before the present contract was signed.

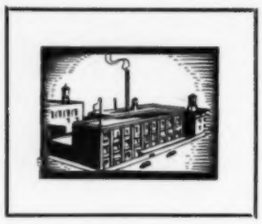
The ten-year contract which is the basis of the arrangement is an interesting engineering document. In last month's issue, the terms of the contract relating to the characteristics of the current interchanged, power factor, electrical loading of the turbines, settlements for steam and electricity, interruptions of delivery of steam, transformers, change in electric or steam rates, quality of steam, etc., were described. In the present article, the provisions of the contract concerning any change from coal to liquid or gaseous fuel, disposition of the old boilers in the Lilly plant,

*Director of Engineering, Eli Lilly and Company, Indianapolis, Ind.

meters and their accuracy, coal cost arbitration, rate for steam, and billing are quoted.

10. Provision for Any Change from Coal Fuel

"The coal clause contained in the Industrial Steam Rate Schedule attached to and made a part of this contract is based on the continuous use by the Power Company of bituminous coal for fuel, having approximately eleven thousand (11,000) British thermal units per pound, and costing approximately $2.40 per net ton delivered at point of use. If any change in the general fuel situation should develop that causes the Power Company to change from the use of coal as a fuel to a liquid or gaseous fuel for steam generating purposes, then it is agreed that the base rate schedule will be based on a cost of ten and ninety-one hundredths cents (10.91c) per million British thermal units, and the coal clause of said Industrial Steam Rate Schedule will be changed as follows:



"If the cost of fuel (liquid or gaseous) as burned by the Power Company shall vary above or below ten and ninety-one hundredths cents (10.91c) for each million Btu delivered at the point of use, there will be no change in the base rate as billed for fuel costs between 9.92 cents per million British thermal units and 12.728 cents per million British thermal units. A change of ten cents (10c) in the cost of a ton of coal is equivalent to a change of 0.4545 cents per million Btu, and there shall be added to or subtracted from the monthly steam bill, for each thousand pounds of steam, the amount as shown in the following table for the average cost of fuel (liquid or gaseous) per each million Btu delivered at point of use.

For a Price of Fuel per Million Btu Delivered	Subtract from Monthly Bill as Computed for Each One Thousand Pounds of Steam
6.1195 cents	5.25 cents
6.5640	4.51
7.0195	3.74
7.4740	2.992
7.7285	2.244
8.1830	1.496
8.6375	0.748
9.092	0.000
10.91	0.000

	Added to Monthly Bill as Computed per Each One Thousand Pounds of Steam
12.728 cents	0.000 cents
13.1825	0.748
13.6270	1.496
14.0815	2.244
14.5360	2.992
14.9905	3.74
15.4450	4.51
15.8995	5.25

11. Old Boilers in Lilly Plant

"The Customer proposes to maintain intact, for at least two years, the boilers now operating, and nothing in this contract shall be interpreted as prohibiting the Customer, from, or penalizing the Customer for, operating the boilers to supply steam during any interruption of deliveries of steam by the Power Company, nor from occasionally operating the boilers for a day to assure the Customer that the boilers can be relied upon for adequate generation of steam in an emergency.

The Customer agrees that said boilers while available may be operated at the expense of the Power Company on Sundays or other periods of low steam demand when it is necessary to stop service on the steam line for maintenance, repairs or other necessary purposes."

12. Meters

"The Power Company will furnish, install and maintain, without cost to the Customer, necessary steam and electric meters to measure accurately the steam and electric energy delivered under this contract.

"All meters shall be located upon the Customer's premises, and the duly authorized representatives of either party shall have access to said meters at all reasonable hours for the purpose of reading, testing, calibrating or adjusting the same. No changes of any kind will be made in the meters or metering equipment by either party except in the presence of representatives of the other party.

"Said meters shall be tested by the Power Company for accuracy at least twice each year, and the Customer shall be notified not less than three days before each test so that the Customer can have a representative present to observe the same.

"In the event that any meter test shows an error of registration of more than two per cent (2%), the billing quantities will be adjusted in accordance with the result of the test for a period of time dating back to one-half the interval of time to the previous test, except where it is obvious that the inaccuracy began at a certain definite time, in which case the adjustment shall date from the obvious beginning of the inaccuracy.

"If for any reason any meter fails to operate during any period, the quantity used for billing purposes shall be determined by pro-rating the quantities for the period, using as a base the quantity consumed during like periods of known accurate measurements, giving full consideration to any changed conditions that would affect the consumption.

"The Customer is privileged to put in such check meters as it deems advisable but at its own expense."

13. $50,000 of Steam per Year Guaranteed

The Lilly Company guarantees to the Power Company, through the ten-year life of the contract, the purchase of steam to at least the extent of $50,000 per year.

14. Coal Cost Arbitration

"The operation of the coal clause in the Industrial Steam Rate Schedule attached to and made a part of this contract, is based upon the cost of mine run bituminous coal having approximately eleven thousand (11,000) British thermal units per pound of

coal as fired. The base rate is based on such coal costing two dollars and forty cents ($2.40) per net ton delivered on cars at the Power Company's steam generating station. In any consideration of the cost of coal it must be recognized that the coal requirements of the Power Company are from seventeen hundred to two thousand tons of coal per day, and a continuous and reliable supply of coal is of first importance. It is also recognized and admitted that there is always a limited amount of distress coal in the open market, due to various and changing conditions. It is not intended by either party that the price of such distress coal shall be a measure of the fair and reasonable cost of coal.

"If and when the cost of coal changes sufficiently, and the coal clause in said Industrial Steam Rate Schedule becomes operative so as to affect the billing for steam delivered under this contract, the Customer may challenge the coal cost as determined by the Power Company, if in the Customer's opinion the coal cost so determined is inconsistent with the market price of coal prevailing for the period in question for coal of equivalent quality and burning characteristics and in comparable quantities.

"When the Customer so challenges the cost of coal it shall notify the Power Company in writing requesting an informal review of the actual coal costs. If the differences of opinion as to coal costs are not reconciled in such informal review, then the parties hereto shall submit the matter to arbitration by an instrument in writing (which shall include an agreement to make the submission a rule of court) under the provisions of the Act of 1852 of the General Assembly of the State of Indiana, together with any acts supplemental thereto or amendatory thereof, as set forth in Burn's Annotated Statutes of 1926, in Sections 926 et seq., so far as the same may be applicable to such controversy. It is agreed that said arbitrators, who shall be appointed within fifteen (15) days after the cost of coal is challenged, shall consist of an official of the Customer as named by it, and an official of the Power Company as named by it, and if these two arbitrators do not agree as to the determination of the controversy, then a third arbitrator shall be jointly selected within ten (10) days by the two said arbitrators.

"The fair market price of mine run coal in comparable quantities, of equivalent quality and burning characteristics theretofore used by the Power Company in the generation of steam under this contract, shall be determined by said arbitrators in the manner and according to the provisions of the aforesaid statute, provided, however, that said arbitrators in their determination of said fair market price shall be bound by the following definition: namely; that for the purposes of this contract, 'fair market price of mine run coal' shall be the general and average price at mine of such coal obtainable in necessary quantities and of 11,000 Btu as offered and sold by various coal mining companies during the period for which the price of coal was challenged by Customer, plus freight thereon from mine to Indianapolis.

"No compensation shall be paid for the services of said two officials. Compensation shall be paid by the losing party to the third arbitrator together with all other costs of such arbitration as may be taxed by the court where such submission is made a rule. It is further agreed that until such controversy is finally determined according to the provision of said statute, the billings of the Power Company for steam delivered to the Customer under this contract shall be paid at the base rate by the Customer. Any adjustment made shall be retroactive for the billing period for which the coal cost was challenged by the Customer."

15. Contract Effective

Contract shall be effective when signed by both parties and approved by the Indiana Public Service Commission.

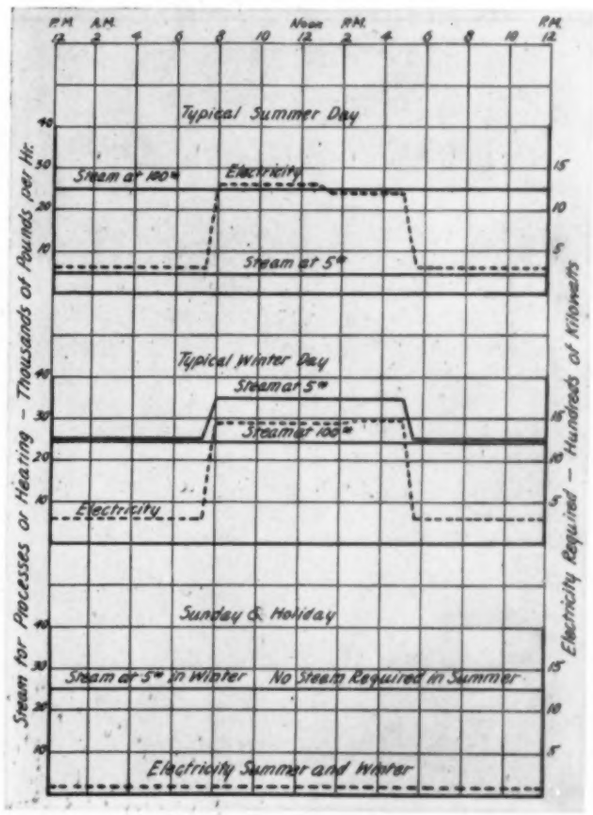
16. Rate for Steam

"$1.10 per thousand pounds of steam for the first thirty (30) hours use of the billing demand per month.

"$0.40 per thousand pounds of steam for the next ninety (90) hours use of the billing demand per month.

"$0.25 per thousand pounds of steam for the next two hundred and forty (240) hours use of the billing demand per month.

"$0.23 per thousand pounds of steam for all in excess of three hundred sixty (360) hours use of the billing demand per month."



PROCESS STEAM AND ELECTRIC REQUIREMENTS OF LILLY PLANT

17. Payments Made Monthly

Payments for steam to be made monthly with 2% discount if paid within ten days of date of bill.

18. Billing Demand for Steam

"The billing demand shall be the maximum average demand for a thirty-minute period, measured in thousands of pounds per hour, during the month for which the bill is rendered, but in no case shall the billing demand be less than seventy-five per cent of the maximum thirty-minute demand during the preceding eleven months."

19. The Billing Month

"This rate is based on a billing month of thirty days and any variation from a thirty-day period will be compensated for by adjusting the hours use of billing demand to correspond with the actual number of days billed."

20. Coal Clause

"If the average cost of coal as burned in the Power Company's generating station, during the calendar month immediately preceding the regular meter reading date for the current month, shall vary above or below $2.40 per net ton delivered on cars at the Company's steam generating station, then there shall be an increase or decrease of seventy-five hundredths of a cent per thousand pounds of steam for each ten cents increase above $2.80 per net ton, or a ten-cent decrease below $2.00 per net ton delivered on cars at the Company's steam generating station."

Insulation of Cold-Water Lines

OUR experience in the insulation of cold water lines leads us to disagree with the conclusions of Herbert Chase, author of "Preventing Drip from Pipes" [1]. To begin with, the amount of insulation necessary to prevent condensation on pipes is an exact function of the maximum difference of temperature between the water in the pipe and the room, the maximum degree of humidity in the room and the transmission coefficient of whatever insulation is applied to the pipes. These factors can be readily ascertained and the precise amount of insulation necessary can be computed with considerable exactness. We have never heard of a rule-of-thumb method which will suffice.

Our chief objection to Mr. Chase's article lies in the fact that his solution for condensation applies only in cases where condensation is formed by a very narrow margin. The insulation that he describes, namely, painting the pipes and painting them with the addition of granulated cork gives very slight insulation. The greater part of the article is devoted to a dissertation on how to paint pipes, which, while doubtless a valuable contribution to the art, does not appear to answer the question brought up by his subject.

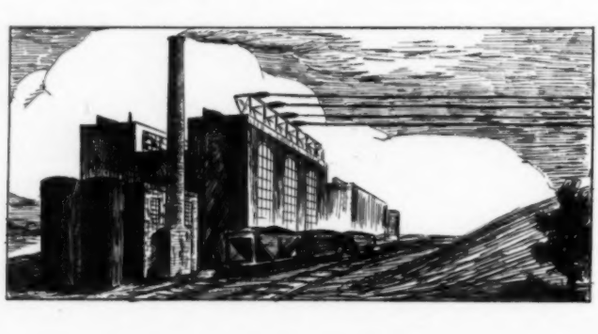
Molded cork pipe covering has been established as an economical and sightly form of low-temperature pipe insulation; its efficiency in relation to its bulk is well known. However, we find that for cold water insulation where there is a high degree of humidity, it is necessary to use at least 1½ in. of molded cork pipe covering, and in some industries where the humidity approaches 90 per cent or higher, it is frequently necessary to go to 2½ in. of covering in order to prevent condensation. It will be realized from the above that a few granules of cork on top of a coat of paint is not apt to be adequate for the service to which Mr. Chase intends to put his insulation.—*T. E. Willson, Jr.,* Chief Engineer, Mundet Cork Corp., New York City.

The Author Comments

Probably nobody will take exception to the contention that molded cork is an efficient and otherwise excellent covering for low-temperature pipes that are to be insulated in such a way as to prevent condensation and transfer of heat from the air of a room to a cold liquid within the pipe. It is true also that the amount or thickness of insulation required is determined by the temperature difference, the degree of humidity and the coefficient of heat transmission of the insulating material used. In addition, it is conceded that there undoubtedly are conditions under which a relatively thin insulating coating of granulated cork applied in the manner indicated in my brief article would not be adequate to prevent condensation.

I am reliably informed, however, that the method of insulation described by me is adequate for preventing drip from cold surfaces under many conditions and is successfully used for this purpose. As indicated in my article, it is used aboard ship, where the humidity is certainly likely to be high and the water pumped through pipes is often very cold. For this reason it seems to be a fair conclusion that similar practice can be followed with success in many industrial applications. I have not said, nor do I contend, that the practice is suitable for all conditions.—*Herbert Chase.*

[1] See p. 327, April, 1932, Heating, Piping and Air Conditioning.



Heating·Piping
Air Conditioning

American Society of Heating and Ventilating Engineers
JOURNAL SECTION

1895

JUNE 1932

Material in this Section prepared by Publication Committee: F. D. Mensing, *Chairman;*
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Natural Wind Velocity Gradients Near a Wall

By J. L. Blackshaw[1] and F. C. Houghten,[2] (*MEMBERS*) Pittsburgh, Pa.

IN 1931 the Research Laboratory of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, in co-operation with the United States Bureau of Mines, published a paper[3] which included a study of wind velocity gradients resulting from the frictional effect of the wind near a wall in free space. The results of this investigation were useful in converting film resistance coefficients obtained with apparatus having confining ducts to coefficients applicable to open air conditions found on actual building surfaces.

In setting up the apparatus for the earlier study, it seemed impractical to arrange the equipment on the wall of a building and wait for favorable winds with which to determine velocities; a wind tunnel was not considered because it would produce the undesired duct condition. Rather than to move air past a test wall, it was decided to move a test panel through the air and thus artificially produce an effect similar to that of natural wind blowing parallel to a wall. This was done by driving a truck, with a panel erected on its side, at uniform velocities along a level stretch of road at times when there was no natural wind blowing. This earlier paper contained, in addition to information on velocity gradients obtained with the truck, other data covering velocity gradients in ducts. Velocity gradient curves obtained in the earlier study are shown in Fig. 1 for a surface in free space, in a 12-in. duct, and in a 6-in. duct for wind velocities of 10, 20, and 30 mph, respectively.

Some question was raised concerning the application of the results obtained by the survey made with the moving truck to conditions of natural air flow near an actual wall. There was the possibility that waves of air set up by the front of the truck and eddy currents from its undercarriage would have affected the data. With this in mind, the Committee on Research and the Technical Advisory Committee on Heat Transmission authorized a new study on velocity gradients in free space to be made under natural wind conditions using a stationary panel located at a vantage point subjected to free air flow.

A search was made about Pittsburgh and its environs to find a suitable spot for the erection of a swiveled test panel where it would be exposed to unrestricted natural winds. The bald top of one of Pittsburgh's hills could have been used, but the roof of an isolated high building was considered more adaptable. Through the courtesy of Chancellor Bowman of the University of Pittsburgh, the top of the Cathedral of Learning of the Uni-

[1] Research Engineer, A.S.H.V.E. Laboratory, Pittsburgh, Pa.
[2] Director, A.S.H.V.E. Laboratory, Pittsburgh, Pa.
[3] Wind Velocity Gradients Near a Surface and Their Effect on Film Conductance, by F. C. Houghten and Paul McDermott. (*Heating, Piping and Air Conditioning*, March 1931, p. 229.)

For presentation at the Semi-Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Milwaukee, Wis., June 1932.

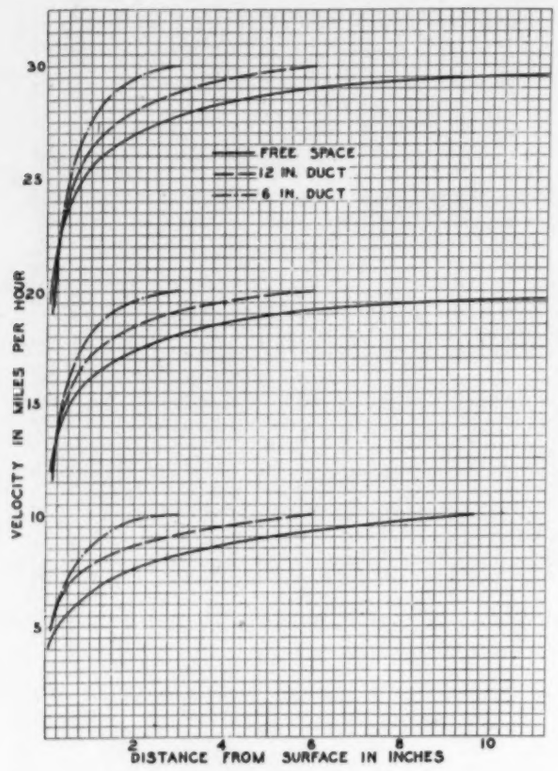


FIG. 1—VELOCITY GRADIENTS FOR A SURFACE IN FREE SPACE AND IN 12-IN. AND 6-IN. DUCTS

versity was made available to the Laboratory for this project. The Cathedral of Learning, now being constructed at a cost of more than $8,000,000 has 41 stories and is 535 ft high. (See Fig. 2).

At the top of this building is a 30 ft square observation platform that is entirely clear of all obstructions except a small temporary elevator scaffold and an airplane beacon, neither of which blankets more than a few feet of wind flow area. This platform offered an ideal location for the test equipment, which was similar to that built on the moving truck in the earlier study as to the type of panel and velocity tubes used and the photographic method employed to simultaneously record the pressures indicated by the velocity measuring tubes.

Description of Apparatus

The front of the test panel in position for this work is pictured in Fig. 3, and a line drawing of the set-up is shown in Fig. 4. The rigid ¼-in. thick composition board panel, *A*, 6 ft high and 12 ft long, painted with gray wall paint, was held securely 2 ft above the floor by light, braced framework. This framework, designed to withstand a 90-mph wind blowing perpendicular to the panel, was firmly anchored to the concrete floor of the observation platform at *B* with a swivel coupling, which permitted the panel and recording apparatus to be turned through a complete revolution to bring the face of the panel parallel to the direction of air flow. A wind vane, *C*, indicated the direction of the air stream by means of a pointer. The cup anemometer, *D*, recorded the average wind velocity during any test run.

For the study on velocity gradients twelve velocity measuring tubes were held in the panel in a vertical plane at *E*, 8 ft from the leading edge of the panel, *F*, and were set to protrude progressive distances from the face of the panel. Six of these tubes were special tubes made from hypodermic needle tubing with an inside diameter of 0.0531 in. and an outside diameter of 0.0720 in., which, having so little bulk, allowed pressures to be measured close to the wall with little interference of the air stream. They recorded total pressures only. Static pressures were determined in a static pressure box, *G*, which had fourteen 0.040 in. holes drilled in it perpendicular to its ⅛-in. brass face, which was sunk flush into the panel near the tubes. If this static chamber, *G*, were connected to one leg of an inclined draft gage, and a total pressure tube were connected to the other, the displacement of the liquid in the gage would give the velocity pressure from which the velocity of the air could be determined. The other 6 tubes were standard Pitot tubes having an outer tube to indicate static pressure and an inner one to indicate total pressure. If the outer tube were connected to one leg of an inclined draft gage and the inner tube were connected to the other, the displacement of the liquid in the gage would give the velocity pressure from which the velocity of the air could be determined. A thirteenth standard Pitot tube, *H*, was held at a point half-way up the panel but only 2 ft from the leading edge. In the set-up for velocity gradients, the type of tube and its position, protrusion, and distance from the floor and the leading edge are given in Table 1.

FIG. 2—THE CATHEDRAL OF LEARNING OF THE UNIVERSITY OF PITTSBURGH PHOTOGRAPHED FROM THE OFFICE WINDOW OF THE A. S. H. V. E. RESEARCH LABORATORY LOCATED IN THE PITTSBURGH EXPERIMENT STATION OF THE U. S. BUREAU OF MINES

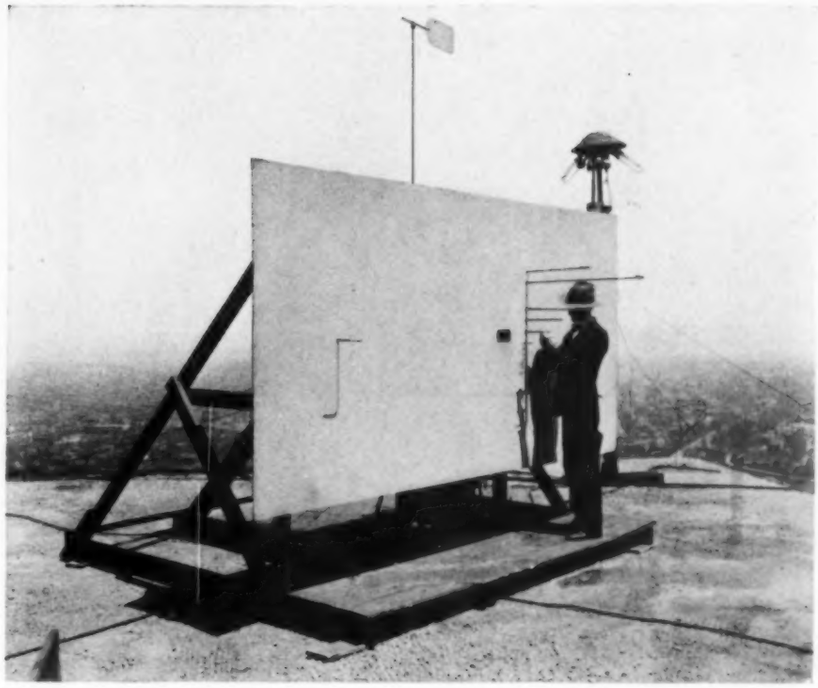


FIG. 3—FRONT OF TEST PANEL USED IN STUDY OF VELOCITY GRADIENTS

In Fig. 4, *J* indicates an adjustable inclined manometer frame which supported 13 draft gages to which all 13 velocity tubes were connected by rubber tubing. Obviously it would be imposible for an observer to read all 13 gages at the same time, especially in a varying wind, so they were read photographically by using a light bank and a motion picture camera in a manner similar to that used in the previous study. This method again proved entirely satisfactory. Fig. 5 is a photograph of the back of the test panel showing the connections and apparatus used.

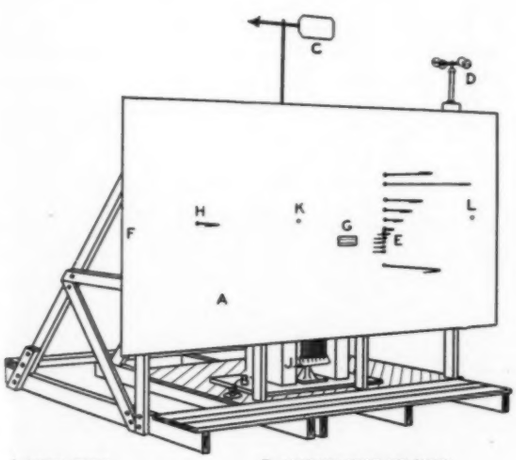
A short strip of film obtained by the photographic method is shown in Fig. 6. After development, each picture was enlarged by projection onto a screen where the displacement of the colored alcohol in the gages could be accurately read with the aid of a calibrated scale. The two lines at the left of each individual picture of the film strip are gage points for setting the scale in taking displacement readings. The numbers at the lower left hand corners refer to data recorded at the time the picture was taken, covering wet- and dry-bulb temperatures, the angle at which the manometer was set, the barometric reading, or any other observations made. Data were disregarded whenever successive pictures showed that the wind velocity or direction had become too variable for test purposes.

The velocity of the air was determined through the use of the formula:

$$V = 12.4568\sqrt{\frac{h \times \sin \alpha \times D}{w}} \qquad (1)$$

where

V = velocity of the air in miles per hour.
h = displacement of the gage fluid in inches.
α = angle the manometer made with the horizontal.



A—TEST PANEL
B—SWIVEL ANCHOR
C—WIND VANE
D—CUP ANEMOMETER
E—VELOCITY MEASURING TUBES
F—LEADING EDGE OF PANEL
G—STATIC PRESSURE BOX
H—LEADING PITOT TUBE
J—DRAFT GAGES
K,L—OPENINGS FOR PITOT TUBES

FIG. 4—SET-UP USED IN STUDY OF VELOCITY GRADIENTS

TABLE 1

TUBE NO.	KIND OF TUBE	PROTRUSION (INCHES)	DISTANCE FROM FLOOR	DISTANCE FROM LEADING EDGE (FEET)
1	Standard Pitot	20	3 ft. 10½ in.	8
2	Special	½	4 ft. 2½ in.	8
3	Special	¼	4 ft. 4 in.	8
4	Special	½	4 ft. 5½ in.	8
5	Special	1	4 ft. 7½ in.	8
6	Special	2	4 ft. 8½ in.	8
7	Special	4	4 ft. 10 in.	8
8	Standard Pitot	8	5 ft. 1 in.	8
9	Standard Pitot	12	5 ft. 4 in.	8
10	Standard Pitot	16	5 ft. 7 in.	8
11	Standard Pitot	36	6 ft. 0 in.	8
12	Standard Pitot	24	6 ft. 3 in.	8
13	Standard Pitot	8	5 ft. 1 in.	2

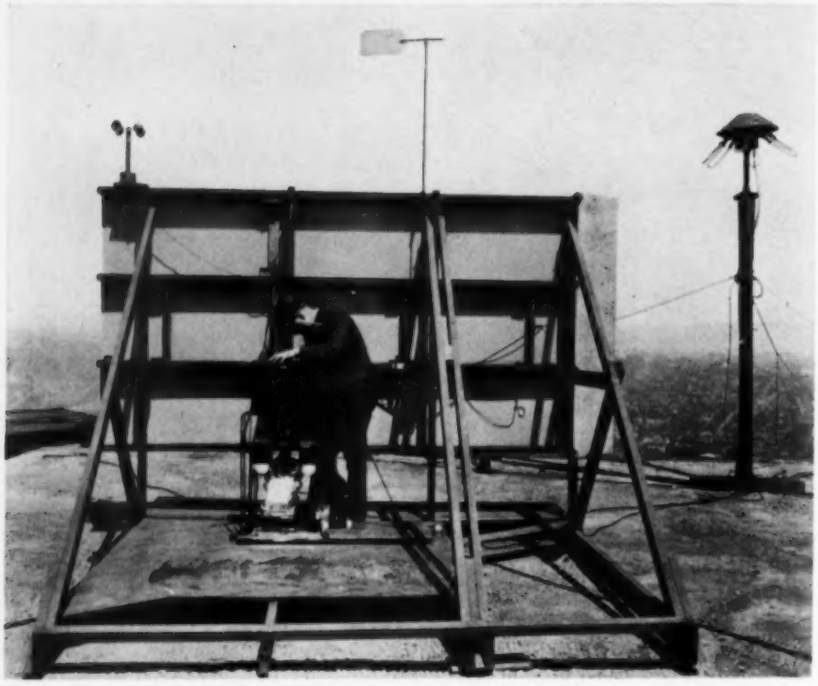


FIG. 5—BACK OF TEST PANEL USED IN STUDY OF VELOCITY GRADIENTS

D = specific gravity of the gage fluid at the temperature of the gage.
w = weight of the air in pounds per cubic foot for the prevailing wet- and dry-bulb temperature and barometric pressure.

In Formula 1, w may be quickly determined without a laborious mathematical process by reference to the Younger chart[4].

Test Procedure

In taking data, the panel was turned until the wind vane indicated a parallel flow of air past the tubes. All tubing and connections were checked for possible leaks. After leveling the inclined manometer and recording the angle at which it was set, the operator waited until a parallel and steady wind gave a fairly constant displacement of the fluid in the gages. In photographing the manometer, the camera was adjusted to record approximately two pictures a second.

In a preliminary run to calibrate the tubes, all 13 velocity tubes were set so they protruded an equal distance from the panel, and data were taken from which a calibration curve could be drawn for each tube to correct it for position and to even out any slight differences which might be found among the tubes. In a second preliminary run, tubes No. 9 and 10 were taken out of the vertical plane, E, and again protruded equidistant from the panel at points K and L in a horizontal plane midway of the panel, in order that readings of the gages would show any possible horizontal wind velocity gradient. In the test none was found.

After this preliminary information had been obtained, the tubes were adjusted in the panel to protrude the respective distances given in Column 3 of Table 1. Pitot Tube 13 protruded the same distance from the panel as Pitot Tube 8 and was in the same horizontal plane with it; therefore, identical readings of Tubes 8 and 13 indicated an air flow parallel to the panel. Because Pitot Tube 1, lowest in the line of tubes, stuck out nearly as far as the two upper tubes, it recorded any disturbing effect of turbulence or diagonal air flow across the panel.

The solid line curve in Fig. 7 connects 12 points

[4] Chart for Determining the Weight of Moist Air, by John E. Younger. (*Mechanical Engineering*, June 1925, pp. 492.)

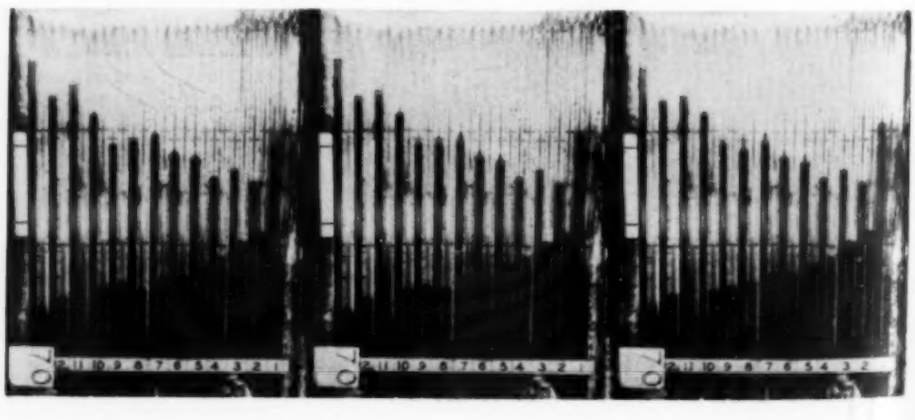


FIG. 6—MOTION PICTURE FILM SHOWING TYPICAL MANOMETER GAGE DISPLACEMENTS

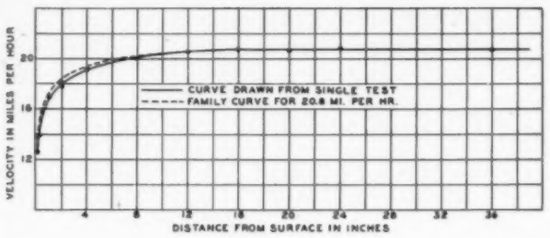


FIG. 7—WIND VELOCITY GRADIENT FOR SINGLE TEST AND FAMILY CURVE FOR THIS VELOCITY

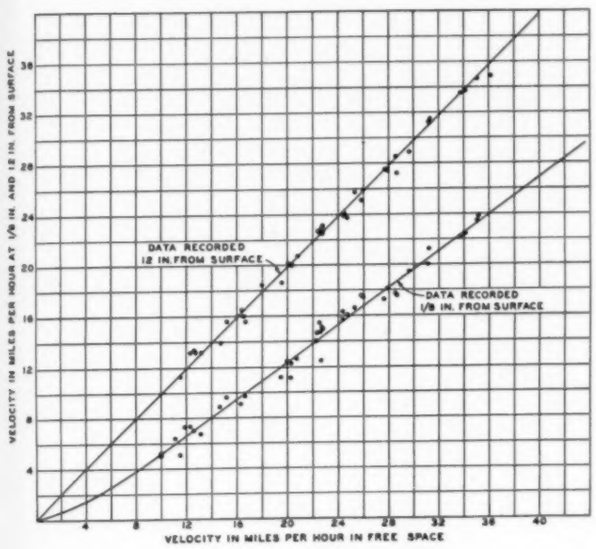

VELOCITY IN MILES PER HOUR AT 1/8 IN. AND 12 IN. FROM SURFACE
DATA RECORDED 12 IN. FROM SURFACE
DATA RECORDED 1/8 IN. FROM SURFACE
VELOCITY IN MILES PER HOUR IN FREE SPACE

FIG. 8—RELATION BETWEEN VELOCITY IN FREE SPACE AND VELOCITIES AT POINTS ⅛-IN. AND 12-IN. FROM THE SURFACE

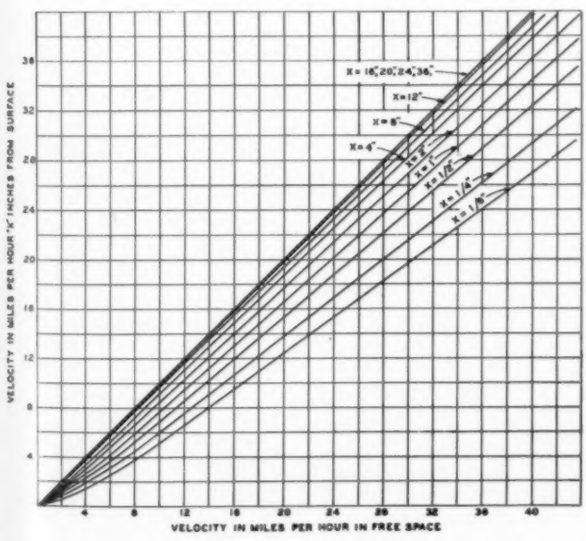


FIG. 9—RELATION BETWEEN VELOCITY IN FREE SPACE AND VELOCITIES AT POINTS AT WHICH VELOCITY TUBES WERE LOCATED

showing the respective positions of the 12 tubes and the velocities which were indicated by them experimentally in a single test. The curve gives a typical velocity gradient away from the panel for a free wind velocity of 20.8 mph.

Data and Results

Fig. 8 gives typical experimental data showing the relation between the velocity in free space and the velocities found at points ⅛-in. and 12-in. from the panel, as determined respectively by Tubes No. 2 and No. 9 in a series of test runs. The free wind velocities were taken as the velocities given by Tube No. 11. Tubes 1, 10 and 12 indicated the same velocities as Tube 11 which showed that the air stream beyond Tube 10 was unaffected by the resistance of the surface.

Curves similiarly plotted are shown in Fig. 9 for all 12 tubes to compare free wind velocities with velocities at the varying distances from the surface given as X in the drawing. The curves tend to pack together as the distance from the surface increases. Except at the higher velocities, these curves check almost exactly with similar curves obtained from data taken with the moving truck in the earlier work. The fanning of the curves at the higher velocities might be due to the greater air speed obtained with the artificially produced wind created by the truck.

From Fig. 9, data were obtained to plot the family of velocity gradient curves away from the surface which are shown in Fig. 10. The heavy solid line curves are the gradient curves away from the panel for the natural wind on top of the Cathedral of Learning, and are plotted for free wind flow conditions of 10, 20, 30 and 40 mph. Similar curves obtained in the earlier work

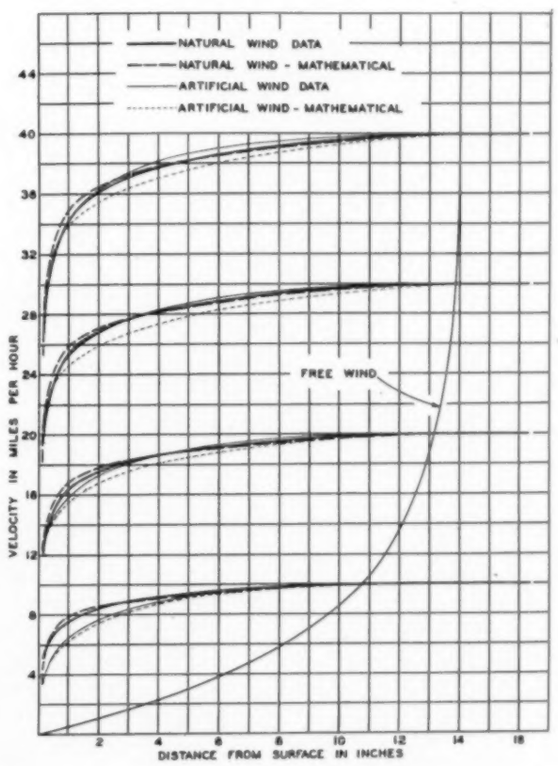


FIG. 10—VELOCITY GRADIENT CURVES NEAR THE TEST PANEL SHOWING COMPARATIVE FAMILY AND MATHEMATICAL CURVES

with the artificially created wind are drawn in this figure as the light solid line curves. It may be seen that the two separate studies check closely except at low velocities. At a free wind condition of 10 mph and at 1-in. from the surface, there is a difference between the curve of 1.5 mph, which discrepancy may be explained by the fact that the measuring tubes are insensitive at low velocities. Data below 12 mph were extrapolated in both the natural and the artificial wind tests.

At any desired velocity in free wind, a family velocity gradient curve may be read from Fig. 9. Such family curve was read for 20.8 mph free wind velocity and was plotted in Fig. 7 together with the typical experimental curve at 20.8 mph drawn from actual test data. The curves lie closely together.

As the data shown in Fig. 9 consisted of straight lines passing through different Y axis intercepts, it seemed probable that the data should fit a logarithmic curve. By using logarithmic paper and, in each case, plotting distance from the surface as one ordinate and the slope of the straight line as the other, a relationship between free wind velocity and velocity at any distance from the surface was determined to be:

$$V_x = V_f \left(\frac{X - 0.123}{13.877} \right)^{0.03623} - \left(\frac{1.4}{\sqrt{X}} - 0.27 \right) \qquad (2)$$

where

V_x = velocity of wind at X distance from the surface.
V_f = velocity of wind in free space.
X = distance from the surface in inches.

The accuracy of this formula is shown on Fig. 10 by the coincidence of the heavy dash line calculated curve with the heavy solid line curve derived from test data.

The mathematical curves presented in the earlier paper for the respective four free wind velocities are superimposed on Fig. 10 by the light dash lines. The curve marked *Free Wind* on Fig. 10 connects the points where the various velocity gradient curves become asymptotic and marks the end of the gradient effect caused by the surface, and the beginning of unrestricted wind flow.

A chart, Fig. 11, for correlating air velocity gradients in ducts and in free space has been developed from laboratory data. With this chart, any three of four factors (*i.e.*, width of duct, air velocity at center of duct, distance X from duct surface, and air velocity at distance X) may be combined to give the fourth factor. Since it has been shown that beyond 14 in. the resistance offered by a surface has little appreciable effect on the air stream, a duct 28 in. wide or larger should give a gradient condition similar to that of free space. On the chart, the free space line is identical to that for the 28 in. duct.

Example: What is the air velocity 1 in. from the surface of a duct 12 in. wide, when the air velocity at the center of the duct is 20.5 mph?

Solution from dotted line on chart: Find width of duct, 12 in. at *A*. Follow ordinate to intersection with distance from surface, 1 in., at *B*. Follow oblique line to intersection with heavy line at *C*. Find *E*, 17.6 mph, or the required velocity 1 in. from the surface, by the intersection of the abscissa *CE* and the ordinate *DE* which is drawn through the velocity at the center of the duct, 20.5 mph.

Conclusions

The study on velocity gradients made under natural wind flow conditions on top of a high building shows substantially the same results as those obtained under artificial wind flow conditions produced with a moving truck. A smooth plane wall section was used in both set-ups, and it is possible that the gradient curves obtained would have to be adjusted when figuring for rough walls. A formula for free space and a chart for ducts and free space are given to show the relation between free wind velocity and velocity at any distance from the surface.

Acknowledgments

The authors acknowledge the co-operation extended by Prof. J. A. Dent, John Weber, and J. E. McLean of the University of Pittsburgh in arranging for the study at the Cathedral of Learning.

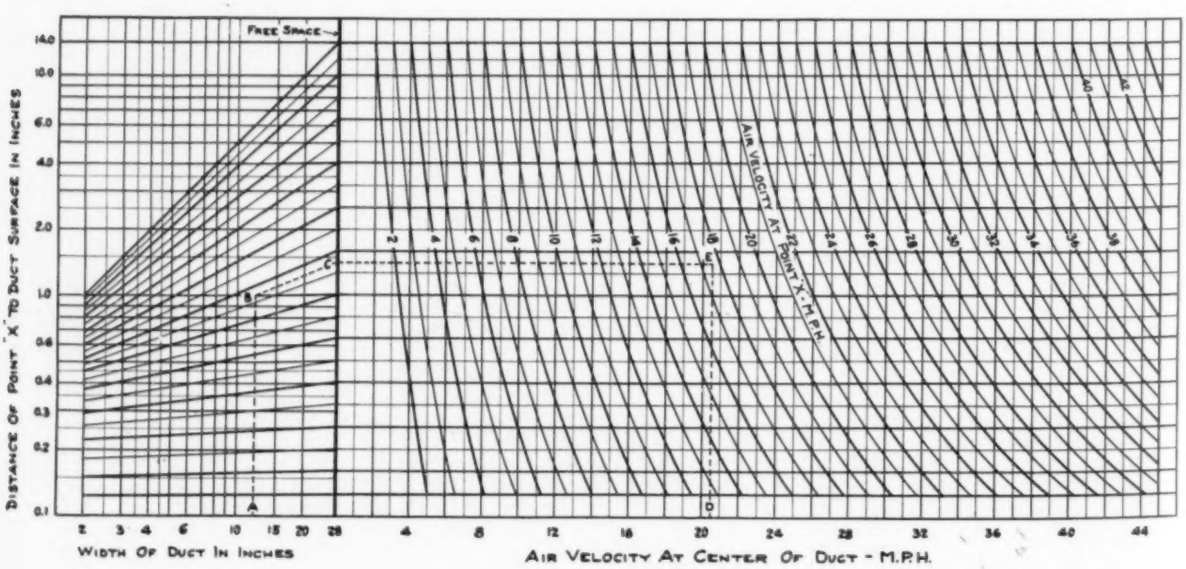

FREE SPACE
DISTANCE OF POINT "X" TO DUCT SURFACE IN INCHES
AIR VELOCITY AT POINT X - M.P.H.
WIDTH OF DUCT IN INCHES
AIR VELOCITY AT CENTER OF DUCT - M.P.H.

FIG. 11—CHART FOR DETERMINING AIR VELOCITY GRADIENTS IN DUCTS AND IN FREE SPACE

How to Use the Effective Temperature Index and Comfort Charts

Report on the True Significance and Limitations of the Effective Temperature Index and Comfort Charts prepared by the Technical Advisory Committee on Re-Study of Comfort Chart and Comfort Line, by C. P. Yaglou, Chairman, W. H. Carrier, Dr. E. V. Hill, F. C. Houghten and J. H. Walker.

SINCE the effective temperature indices and comfort zones were determined seven years ago, there has been some confusion concerning the true significance, application and limitations of these findings, in the minds of those who have not followed the literature closely. This is due probably to the great number of progress reports on the subject and to insufficient qualification of the results and conclusions. The purpose of this report is to clarify the obscure points and to fix, in the light of present knowledge, desirable comfort standards for practical use.

Significance and Application of Effective Temperature Index

Effective temperature is an index of warmth or cold. It is not in itself an index of comfort, as it is often assumed to be, nor are the effective temperature lines necessarily lines of equal comfort. This is true because in determining this index, the subjects compared not the relative comfort, but rather the relative warmth or cold of various air conditions. Moist air at a comparatively low temperature, and dry air at a higher temperature may both feel as warm as air of an intermediate temperature and humidity, but the *comfort* experienced in the three air conditions would be quite different, although the effective temperature is the same. The intermediate condition may be entirely comfortable, but the other two would not measure up to the same standard.

Under extreme humidity conditions there seems to be a difference between sensations of absolute comfort and proper degree of warmth. In other words, human beings are not necessarily comfortable when the air is neither *too warm* nor *too cold*. Air of proper warmth may, for instance, contain excessive water vapor, and in this way interfere with the normal physiologic loss of moisture from the skin, leading to damp skin and clothing and producing more or less discomfort; or the air may be excessively dry, producing appreciable discomfort to the mucous membrane of the nose and to the skin which dries up and becomes chapped from too rapid loss of moisture. According to the comfort experiments both at the A. S. H. V. E. Laboratory in Pittsburgh, and at the Harvard School of Public Health in Boston, effective temperature appears to be a fair index of comfort also, only within a humidity range of 30 to 60 per cent, approximately.

Briefly, *effective temperature* may be defined as an arbitrary index of the degree of warmth or cold felt by the human body in response to temperature, humidity, and movement of the air. Effective temperature is not a temperature at all; it is a composite index which combines the readings of temperature, humidity and air motion in a single value. It has been called *effective* temperature because experiments showed that it is this composite index which initiates the physiologic *effects* produced in the body by heat or cold, regardless of the temperature, humidity and air movement components. The numerical value of the effective temperature index for any given air condition is fixed by the temperature of saturated air which, at a velocity or turbulence of 15 to 25 fpm, induces a sensation of warmth or cold like that of the given condition. Thus, an air condition has an effective temperature of 65 deg when it induces a sensation of warmth like that experienced in practically still air of 65 F saturated with moisture.

In all reports of the A. S. H. V. E. Research Laboratory, the term *still air* signifies the minimum air movement that was possible to obtain in the Laboratory's psychrometric chamber. Actually, the air motion was between 15 and 25 fpm in all experiments, without qualification as measured by the Kata thermometer. This was not a linear movement of air but it represented the turbulence or eddy currents produced by the air change. Even in tightly sealed rooms, the natural air movement is not likely to fall below 10 fpm so long as there is a temperature or pressure difference between the air inside and outside the room. In order to avoid misunderstanding, the committee recommends that in all future papers and charts, the term *still air* be replaced by the actual air movement or turbulence as determined by the Kata thermometer.

Given the dry- and wet-bulb temperature and the velocity of air motion, the effective temperature may be determined from the thermometric chart (Fig. 1) or from psychrometric charts with the effective temperature lines for various air velocities superimposed [1-2]. All these charts should be used specifically as effective temperature charts and not as comfort charts. Those showing the comfort zones for air velocities other than 15 to 25 fpm (often referred to as still air) should be redrawn, omitting the comfort zones for reasons explained later.

For presentation at the Semi-Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Milwaukee, Wis., June 1932.

[1] Effective Temperature with Clothing, by C. P. Yaglou and W. E. Miller. (A. S. H. V. E. TRANSACTIONS, Vol. 31, 1925, p. 89).
[2] A. S. H. V. E. GUIDE 1932.

The thermometric chart (Fig. 1) applies to average normal and healthy persons adapted to American living and working conditions. Application is limited to sedentary or light muscular activity, and to rooms heated by the usual American convection methods (warm air, plenum and direct hot water and steam heating systems) in which the difference between the air and wall surface temperatures may not be great. The chart does not apply to rooms heated by radiant methods such as the British panel system, open coal fires, and the like. It will probably not apply with adequate accuracy to races other than the white or perhaps to inhabitants of other countries where the living conditions, climate, heating methods, clothing, etc., are materially different from those of the subjects employed in experiments at the A. S. H. V. E. Research Laboratory at Pittsburgh.

The effective temperature index for persons doing medium or heavy muscular work, in still air, is given in another paper.[3]

Limits of Comfort Zone, Comfort Line and Comfortable Humidities

According to the definition of the A. S. H. V. E. Research Laboratory, the *extreme comfort zone* includes air conditions in which one or more of the experimental subjects were comfortable. The *average comfort zone* includes those air conditions in which the majority of the subjects (50 per cent or more) were comfortable. That particular effective temperature at which the maximum number of subjects was comfortable was called the *comfort line*.

In some publications the comfort line for the winter season is placed at 64 deg ET, while in others it is put at 66 deg ET. Similarly the lower boundary of the average comfort zone is put at 61 deg and 63 deg ET, and the upper boundary at 69 deg and 71 deg ET.

[3] Effective Temperature for Persons Lightly Clothed and Working in Still Air, by F. C. Houghten, W. W. Teague and W. E. Miller (A. S. H. V. E. Transactions, Vol. 32, 1926, p. 315).

A reference to the original reports will show that the A. S. H. V. E. Research Laboratory has developed two different scales of effective temperature: the basic[4-5-6], and the normal[1], and but one *comfort zone*[7]. In determining the basic scale, the subjects were stripped to the waist to eliminate the complicated influence of clothing. In the normal scale, the subjects wore customary indoor clothing. This is the scale used in ordinary ventilation work. The basic scale is applicable to hot industries where men usually strip to the waist.

The winter comfort zone was determined in 1923 at the A. S. H. V. E. Research Laboratory from votes of

[1] Effective Temperature with Clothing, by C. P. Yaglou and W. E. Miller (A. S. H. V. E. Transactions, Vol. 31, 1925, p. 89).

[4] Determining Lines of Equal Comfort (Warmth), by F. C. Houghten and C. P. Yaglou (A. S. H. V. E. Transactions, Vol. 29, 1923, p. 163).

[5] Cooling Effect on Human Beings Produced by Various Air Velocities, by F. C. Houghten and C. P. Yaglou (A. S. H. V. E. Transactions, Vol. 30, 1924, p. 193).

[6] Effective Temperature Applied to Industrial Ventilation Problems, by C. P. Yaglou and W. E. Miller (A. S. H. V. E. Transactions, Vol. 30, 1924, p. 339).

[7] Determination of the Comfort Zone, by F. C. Houghten and C. P. Yaglou (A. S. H. V. E. Transactions, Vol. 29, 1923, p. 361).

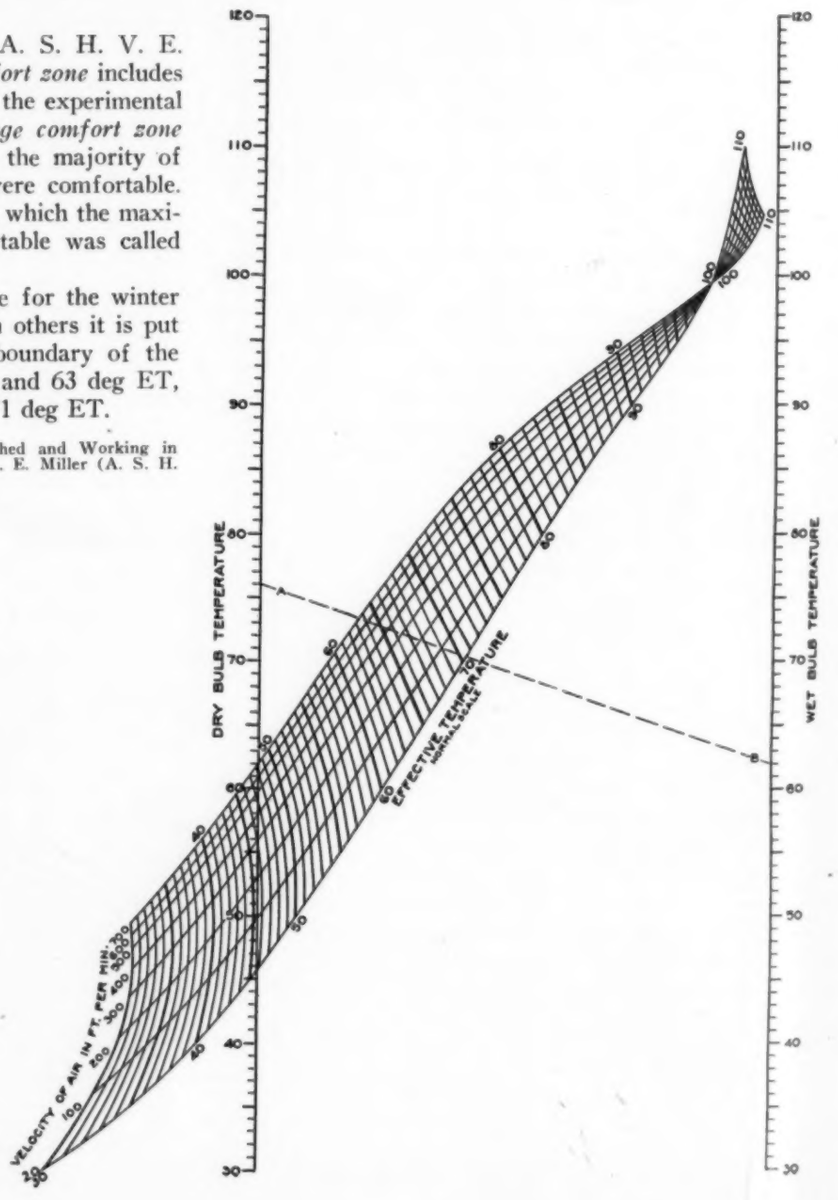


Fig. 1—Thermometric Chart Showing Normal Scale of Effective Temperature. Applicable to Inhabitants of the United States Under Following Conditions:

A. Clothing: customary indoor clothing

B. Activity: sedentary or light muscular work

C. Heating methods: convection type, *i. e.* warm air, direct steam or hot water radiators, plenum systems.

Example in the use of the chart: Given dry-bulb temperature of 76 F, wet bulb temperature of 62 F, velocity of air 100 fpm; determine: (1) effective temperature of the condition, (2) effective temperature with *still* air, (3) cooling produced by the movement of the air, (4) velocity necessary to reduce the condition to 66 deg effective temperature.

Solution: (1) Draw line *A-B* through given dry- and wet-bulb temperatures. Its intersection with the 100-fpm curve gives 69 deg for the effective temperature of the condition. (2) Follow line *A-B* to the right to its intersection with the 20-fpm velocity line, and read 70.4 deg for the effective temperature for this velocity or so-called still air. (3) The cooling produced by the movement of the air is 70.4 — 69.0 = 1.4 deg effective temperature. (4) Follow line *A-B* to the left until it crosses the 66-deg ET line. Interpolate velocity value of 340 fpm to which the movement of the air must be increased for maximum comfort.

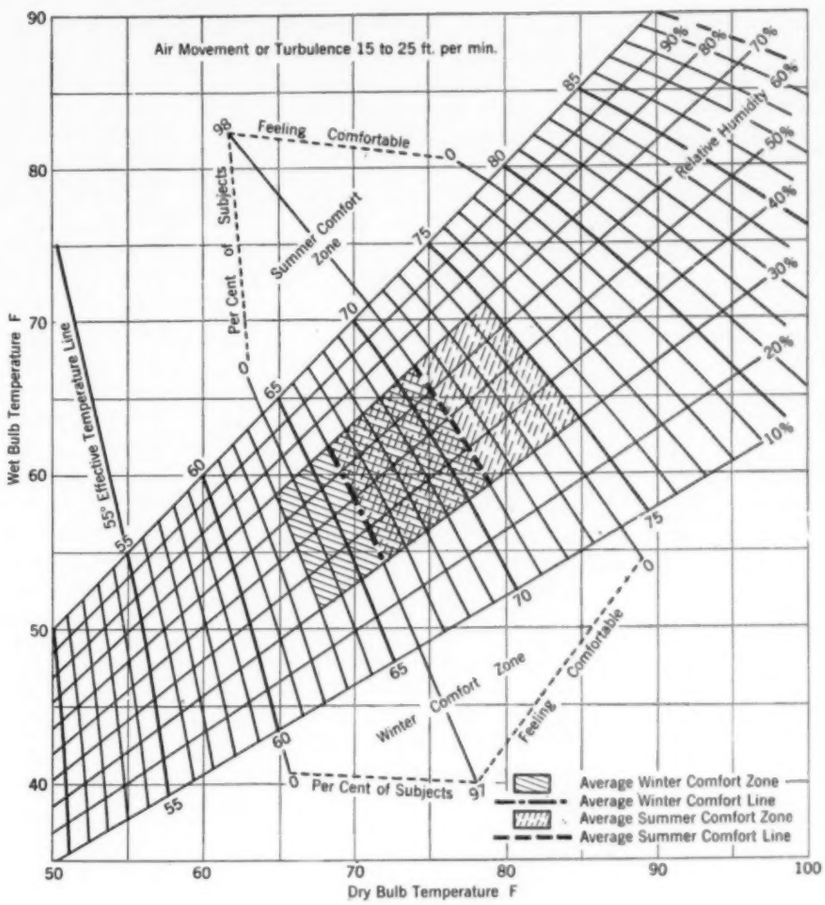


FIG. 2—COMFORT OR EFFECTIVE TEMPERATURE CHART FOR AIR VELOCITIES OF 15 TO 25 FPM (STILL AIR)

Note: Both summer and winter comfort zones apply to inhabitants of the United States only. Application of winter zone is further limited to rooms heated by central station systems of the convection type. The zone does not apply to rooms heated by radiant methods. Application of summer comfort zone is limited to homes, offices and the like, where the occupants become fully adapted to the artificial air conditions. The zone does not apply to theaters, department stores, and the like where the exposure is less than 3 hours.

men and women subjects, wearing customary indoor clothing. This was about one and a half years before the normal effective temperature scale was developed. For this reason, the comfort zone for persons normally clothed was temporarily superimposed on the basic effective temperature chart for persons stripped to the waist. On this basic scale, the limits of the average comfort zone were placed tentatively at 61 and 69 deg and the comfort line at 64 deg basic effective temperature.

In 1924 when the normal effective temperature scale was established, the laboratory recomputed the comfort zone data in terms of this new scale, and superimposed the zone on the new effective temperature chart where it belongs. According to this revision, the average winter comfort zone has been permanently fixed between the limits of 63 and 71 deg ET (normal), and the comfort line at 66 deg ET (normal). This explains the apparent discrepancy.

Another confusing matter which requires clarification is the range of comfortable humidity. In some comfort charts the average winter comfort zone has been extended along the 63 and 71 deg ET lines beyond the experimental limits to include the entire range of relative humidity from 0 to 100 per cent. The implication here is, of course, *not* that either the very dry or the very moist air conditions are entirely comfortable, but that they are equally warm.

In the comfort zone experiments of the A. S. H. V. E. Research Laboratory the relative humidity was varied between the limits of 30 and 70 per cent approximately, but the most comfortable range has not been determined. In similar experiments at the Harvard School of Public Health, a relative humidity of 70 per cent was found to be *somewhat humid* in winter, by about half of the subjects who were stripped to the waist, even when the dry-bulb temperature was 70 F or less. In summer, a relative humidity of 30 per cent was pronounced as *a little too dry* by about a third of the subjects wearing warm-weather clothing. So long as the temperature was kept within proper limits, the majority of the subjects were unable to detect sensations of humidity (*i.e.*, too high, too low, or medium) when the relative humidity was between 30 and 60 per cent. This is in accord with studies by Howell [8], Miura [9], and others.

Until more exact information is secured, it would be desirable to restrict the comfort zones to the range of relative humidity employed in the comfort zone experiments, namely 30 to 70 per cent. Relative humidities below 30 or slightly over 70 may prove satisfactory from the standpoint of comfort, so long as extreme humidities are avoided. From the standpoint of health, however, the consensus seems to favor a relative humidity between 40 and 60 per cent. In mild weather such comparatively high relative humidities are entirely feasible, but in cold or sub-freezing weather they are objectionable on account of condensation and frosting on the windows. They may even cause serious damage to

[8] Humidity and Comfort, by W. H. Howell (*The Science Press*, April 1931).

[9] The Effect of Variation in Relative Humidity upon Skin Temperature and Sense of Comfort, by U. Miura (*American Journal Hygiene*, Vol. 13, 1931, p. 432).

certain building materials of the exposed walls by condensation and freezing of the moisture accumulating inside these materials. Unless special precautions are taken properly to insulate the affected surfaces, it will be necessary to reduce the degree of artificial humidification in sub-freezing weather to less than 40 per cent, according to the outdoor temperature. The principles underlying humidity requirements and limitations are discussed more fully elsewhere [2-10].

The comfort chart (Fig. 2) embodies all the foregoing recommendations of the committee and is submitted to the Society for use as a tentative standard until more exact information is secured. The variation in the sensation of comfort within the zones is indicated by the comfort scales which give the percentage of subjects feeling comfortable at the various air conditions.

The extreme winter comfort zone extends from a minimum effective temperature of 60 deg at which all the subjects of the experiments were too cold, to a maximum of 74 deg, at which all the subjects were too warm. The average winter comfort zone shown by the area shaded with thin solid lines, is included between the 63 and 71 deg ET lines. In a similar way it can be seen that the limits of the extreme summer comfort zones are 64 and 79 deg ET, and those of the average comfort zone, shaded by thin broken lines, 66 and 75 deg ET. The variation from winter to summer is probably due to adaptation to seasonal weather as well as to seasonal variation in the clothing worn [11].

The comfort lines separate the cool air conditions on the left from the warm air conditions on the right. Under the air conditions existing along or defined by the comfort lines, the body is able to maintain thermal equilibrium with its environment, with the least conscious sensation to the individual, or with the minimum physiologic demand on the heat regulating mechanism. This environment involves not only the condition of the air with respect to temperature and humidity but also the condition of the surrounding objects and wall surfaces.

The comfort chart may be reproduced with the zones superimposed on the standard psychrometric chart or on any other suitable chart, but the essential features with respect to air movement and relative humidity limitations should remain unaltered.

Application of Comfort Chart

The average winter comfort line (66 deg ET) applies to average American men and women living inside the broad geographic belt across the United States, in which central heating of the convection type is generally used during four to eight months of the year. It does not apply to rooms heated by radiant energy. In so far as the committee is aware, the Society has never advocated the use of the chart in foreign countries where the climate, heating methods, and general living conditions are materially different from those of this country, though several foreign workers have attempted to show that it cannot be so applied. Even in the warm south and southwestern climates, and in the very cold north-central climate of the United States, the comfort chart would probably have to be modified according to climate, living and working conditions, and the degree of acquired adaptation.

In densely occupied spaces, such as class rooms, theaters, auditoriums, and the like, somewhat lower temperatures are necessary than those indicated by the comfort line on account of counter radiation between the bodies of occupants in close proximity. In rooms in which the average wall surface temperature is considerably below the air temperature, higher air temperatures are necessary. The reverse holds true in radiant or panel heating methods.

The sensation of comfort, insofar as the physical environment is concerned, is not absolute but it varies considerably among certain individuals. Therefore in applying the air conditions indicated by the comfort line the ventilating engineer should not expect all the occupants of a room to feel perfectly comfortable. When the winter comfort line is applied in accordance with the foregoing recommendations, the majority of the occupants will be perfectly comfortable, but there will always be a few who would feel *a bit too cool* and a few *a bit too warm*. These individual differences among the minority may be counteracted by suitable clothing.

It is sometimes argued in the literature that air conditions lying outside the comfort zone have been found perfectly comfortable to certain persons, in cases in which the use of the comfort chart is advocated. If these claims are examined, it will be found that in the majority of them, if not in all, the authors did not appreciate the fact that they were referring to the *average* comfort zone, within which 50 per cent or more of the occupants of a room are expected to be comfortable. In other words, it is possible for half of the occupants of a room to be comfortable in air conditions outside the *average* comfort zone, but in the majority of cases, if not in all, these conditions will be well within the extreme comfort zone as determined experimentally.

Strictly speaking, the only authoritative comfort zone on which accurate data are available is that for 15 to 25 fpm air movement or turbulence (often referred to as still air). In the past, the winter comfort zone has often been superimposed on the thermometric chart or on effective temperature charts for various air velocities, on the assumption that air conditions of equal warmth are approximately equally comfortable. This may hold in hot industries where the workers are adapted to high temperatures and strong air currents, but it does not apply to sedentary conditions such as are found in homes, offices, theaters, and the like, and therefore, the unqualified use of such charts is not advocated. To avoid misunderstanding, these charts should be redrawn with the comfort zones omitted. If one is interested in ascertaining approximately whether a given industrial condition is reasonably comfortable, it would be necessary first to compute the effective temperature from the thermometric chart (Fig. 1) and then refer this effective temperature to the comfort or effective temperature chart (Fig. 2).

The summer comfort line (71 deg ET) is applicable

[2] See A. S. H. V. E. Guide 1932, pp. 67 and 199.

[10] Humidification for Residences, by A. P. Kratz (University of Illinois *Engineering Experiment Station Bulletin No.* 230, July 28, 1931).

[11] The Summer Comfort Zone: Climate and Clothing, by C. P. Yaglou and Philip Drinker (A. S. H. V. E. Transactions, Vol. 35, 1929, p. 269).

to the same geographic area as the winter comfort line. It is further restricted to cases in which the human body has reached thermal equilibrium with its environment. As a general rule this takes place after 1½ to 3 hours exposure. When a person from outdoors enters a room cooled to 71 deg ET on a hot day (95 F or over) an intense chill is likely to be experienced which is unpleasant. However, after remaining in the room for about 2 hours, this fundamental optimum condition will prove satisfactory to the average person. The summer comfort zone, as well as the comfort line, makes proper allowance for these adaptive changes in the body, and thus applies to homes, offices, schools and other similar places where persons of sedentary occupations spend from 3 to 8 or more hours daily.

In artificially cooled theaters, department stores, restaurants, and other public buildings where the period of occupancy is short, the contrast between outdoor and indoor air conditions becomes the deciding factor in regard to the temperature and humidity to be maintained. The object of cooling such places in the summer is not to reduce the temperature to the optimum degree, but to maintain therein a temperature which is temporarily comfortable to the patrons who thus avoid sensations of chill and intense heat on entering and leaving the building. The relative humidity should be low enough (about 50 per cent) to give a sense of comfort without chill and to induce a rate of evaporation which will keep clothing and skin dry. For exposures less than 3 hours, desirable indoor conditions in summer corresponding to various outdoor temperatures are given in Table 1.

Table 1—Desirable Indoor Air Conditions in Summer Corresponding to Outdoor Temperatures

Applicable to Exposures Less Than 3 Hours

Outdoor Temp. (Deg Fahr)	Indoor Air Conditions with Dew-Point Constant at 57 F		
Dry-Bulb	Dry-Bulb	Wet-Bulb	Effective Temp.
95	80.0	65.0	73
90	78.0	64.5	72
85	76.5	64.0	71
80	75.0	63.5	70
75	73.5	63.0	69
70	72.0	62.5	68

The comfort zone and comfort line for men normally clothed and working at the rate of about 33,000 ft-lb per hour are discussed elsewhere[12].

[12] Heat and Moisture Losses from Men at Work and Application to Air Conditioning Problems, by F. C. Houghten, W. W. Teague, W. E. Miller and W. P. Yant (*Heating, Piping and Air Conditioning*, June 1931, p. 493).

Design of Exhaust Systems

The first step in the design of an exhaust system is to determine the number and size of the hoods and their connections. The hood and duct dimensions are determined by the characteristics of the operations to which they are applied. When a tentative decision regarding the setup has been made, it is then necessary to obtain the suction and air velocities required to effect control. The designer at this point must rely considerably on the prevailing practice and on such physical data relating to hoods, duct systems and collectors as are available. Finally, in choosing the fan, the area of the intake should be equal to or greater than the sum of the areas of the branch ducts. The speed, of course, must be sufficient to maintain the calculated suction and air velocities in the system. In general, the most important requirements of an efficient exhaust and collecting system are as follows:

1. Hoods, ducts, fans and collectors should be of adequate size.
2. The air velocities should be sufficient to control and convey the materials collected.
3. The hoods and ducts should not interfere with the operation of a machine or any working part.
4. The system should do the required work with a minimum power consumption.
5. When inflammable dusts and fumes are conveyed, the piping should be provided with an automatic damper in passing through a fire wall.
6. Ducts and all metal parts should be grounded to reduce the danger of dust explosions by static electricity.
7. The design of an exhaust system should afford easy access to parts for inspection and care.

The removal of dust or waste by means of an exhaust hood requires a movement of air at the point of origin sufficient to carry them to a collecting system. The air velocities necessary to accomplish this depend upon the physical properties of the material to be eliminated and the direction and speed with which it is thrown off. If the dust to be removed is already in motion, as is the case with high-speed grinding wheels, the hood should be installed in the path of the particles so that a minimum air volume may effectively be used. It is always desirable to design and locate a hood so that the volume of air necessary to produce results is as low as possible.

The static suction at the throat of a hood is frequently used in practice as a measure of the effectiveness of control. This is of considerable value where exhaust systems adapted to particular operations have been standardized by practice. It must be remembered, however, that the term *suction* is merely a rough measure of the air volume handled and consequently of the air velocity at the opening of the hood. The elimination of any dusty condition requires added information concerning the shape, size and location of the hood used with regard to the operation in question.

In some states grinding, polishing and buffing wheels are subject to regulation by codes. The static suction requirements, which range from 1½ to 5 in. water displacement in a *U*-tube, should be followed although in several instances they may appear to be excessive. Frequently, in these operations, a large part of the wheel must be exposed and the dust-laden air within the hood is thrown outward by the centrifugal action of the wheel, thus counteracting useful inward draft. This tendency may be diminished by locating the connecting duct so as to create an air flow of not less than 200 fpm about the lower rim of the wheel.

Investigation of Air Outlets in Class Room Ventilation

By G. L. Larson[1] (*MEMBER*), D. W. Nelson[2] (*MEMBER*) and R. W. Kubasta, (*NON-MEMBER*), Madison, Wis.

This paper is the result of research conducted at the University of Wisconsin in cooperation with the A. S. H. V. E. Research Laboratory

THE purpose of this investigation was to study the influence of outlet vents on class room ventilation. Air infiltration tests have shown that most wall constructions offer paths for air travel. This is especially true around windows and doors. Plastered walls have been shown to be very resistant to air passage, but along the edges of window and door openings and at baseboards, there are chances for the passage of considerable quantities of air. Infiltration depends upon a difference in pressure; therefore, planned outlet vents have an influence on the infiltration into the room. If smaller outlet vents were to be used or if outlet vents were to be eliminated entirely, the consequent building up of pressure might be sufficient to overcome all infiltration into the heated spaces.

Description of Buildings and Ventilating Systems

The tests were conducted in three school buildings: Dudgeon School of the Madison system, the Mechanical Engineering Building and the main Engineering Building of the University of Wisconsin. Dudgeon School is one of the new buildings of the Madison city system and is equipped with unit ventilators. The units are operated on direct current thus rendering variation in capacity very convenient. The class and drawing rooms of the third floor of the Mechanical Engineering Building are ventilated by a central fan system. A typical class room was selected for tests. In addition to testing with a central fan supply, a unit motor-blower and also a unit ventilator were set up in this room to determine the influence of the type of supply on the results obtained in the outlet vent study. A long series of observations was carried on at the main Engineering Building to determine the variations in air supply with open windows under various temperatures and wind movements. These observations were made with and without outlet vents in the two rooms selected.

The planned outlet vents at Dudgeon consist of an opening in each class room at the floor line from which a sheet metal duct extends vertically upward about 8 ft and discharges into the corridor through a wire grille. Venting from this point takes place through grilles in toilet room doors and also through lockers located in the corridors. The building is a single story in height. The size of the vertical duct in the class room and the grille is 12 in. by 21 in. The floor dimensions of the class room are 22 by 29 ft. Fig. 1 shows a general view of this school room.

The venting of class rooms and drawing rooms in the Mechanical Engineering Building is through louvers placed in the doors leading into the corridors. Venting

FIG. 1 — DUDGEON SCHOOL TEST ROOM

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For presentation at the Semi-Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Milwaukee, Wis., June 1932.

FIG. 2—TEST ROOM AT THE MECHANICAL ENGINEERING BUILDING

FIG. 3—OPEN WINDOW TEST ROOM AT THE ENGINEERING BUILDING

from the corridors is largely through roof ventilators. The dimensions of the typical class room selected for observations are 23 by 32 ft. The gross area of the outlet vent is 5.4 sq ft. Fig. 2 shows this outlet vent.

Two rooms were selected in the main Engineering Building for the open window tests, one on the south side and one opposite this one on the north side of the building. The floor area of the south room was 700 sq ft, and the gross outlet grille area was 5.4 sq ft. The floor area of the north room was 624 sq ft, and the gross outlet grille area was 5.4 sq ft. The vent ducts from various class rooms unite and discharge above the roof. Fig. 3 shows the south room.

FIG. 4—CALIBRATION OF ANEMOMETER ON UNIT VENTILATOR

Calibration Testing

Anemometers were used for air measurements in all cases except with the air delivery from the motor-blower. It was considered advisable to calibrate the particular anemometer used on each grille or louver or open window both for correct registration and for the type of opening on which it was to be used. Two 3-in., two 4-in., and a 6-in. anemometer were used during the program.

In order to determine the true air flow as compared to the anemometer registration, the anemometers were moved through a 26-ft diameter circle on the end of a whirling arm. Electrical contacts and solenoids mounted on the whirling arm were used to start and stop the anemometer registration. The corrections determined for anemometers that had been used for several years checked closely with the manufacturer's determinations. The anemometers were cleaned and oiled before testing.

In all cases this anemometer correction was applied to observed readings. In addition it was considered necessary to determine the correction to be applied to the readings for the type of opening and air flow with which the anemometer was used. This was done for the unit ventilators installed at Dudgeon and the unit ventilator that was temporarily set up in the test class room at the Mechanical Engineering Building. Fig. 4 shows the calibrating arrangement for the latter. A duplicate of the outlet duct in the class room at Dudgeon was set up as shown in Fig. 5, and the calibration of the anemometer was determined for use on this outlet grille. Fig. 6 shows a door of a class room in the Mechanical Engineering Building in position for calibration of the 6-in. anemometer on the outlet louvers.

The anemometer was held against the face of the grille or louver in every case. Air was supplied by a motor-blower and the air measurement was made by Pitot tube traverses. The unit ventilator fan was operated during calibration runs. The air supply was varied at the motor-blower inlet and the corresponding static pressure at the unit

ventilator inlet was observed. These static pressures and the calibration factors for the two unit ventilators tested are shown in Fig. 7. The unit ventilator at the Dudgeon class room was rated at 1350 cfm. The calibration factor determined at zero inlet static pressure was 0.73. The correct air flow under this normal inlet pressure was found to be 1080 cfm without the filter and 950 cfm with a clean filter. The unit ventilator installed for the tests in the class room in the Mechanical Engineering Building was rated at 1200 cfm. At zero inlet static pressure, the calibration factor was 0.87. The correct air flow was determined as 744 cfm without the filter and 615 cfm with a clean filter. The Dudgeon unit had a higher velocity of discharge than did this unit. The lower calibration factor of the Dudgeon unit is accounted for by the fact that the lower row of grille openings was practically inactive. It seems characteristic of anemometers that they measure higher than the average velocity when placed in a position of widely varying velocities. All calibrating was done with the grilles marked off in even squares and the anemometer was kept in contact with the grille the same length of time at each square. The average of the gross and net area was used in each case in figuring air volumes.

The results of the calibration tests for the grille on the outlet duct at Dudgeon and for the louver opening in the door at the Mechanical Engineering Building are shown in Fig. 8. When the 3-in. anemometer was calibrated on the outlet duct, the grille was divided up into four horizontal rows. It was found that the velocity was zero in the two bottom rows. When only the upper half was considered and the average of the net and gross area of this was used, the calibration factor was 1.00. This is in agreement with the results previously determined by the Society.[3]

In calibrating the 6-in. anemometer on the louver opening, the anemometer was held against the louvers and parallel to the face of the door. The louvers are ⅛ in. thick and are placed at an angle of 45 deg. The gross area was based on the width and height through which air passed. In this way the space between the uppermost louver and the edge of the opening margin was not included since it was closed to passage of air at the inner face of the door. The net area was determined by subtracting the area of the vertical dividing bar and the area of the louvers as determined by their length and the thickness perpendicular to their own surfaces. The average of the gross and net area was used in determining the calibration coefficient. The approach section in the duct for calibration had an area about twice the average area of the louver opening. The factor for most of the range varied from 0.80 to 0.85.

[3] See Measurement of Flow of Air Through Registers and Grilles, by L. E. Davies (*Heating, Piping and Air Conditioning*, January 1930 and April 1931).

FIG. 5—CALIBRATION OF ANEMOMETER ON OUTLET DUCT GRILLE

Based on the results obtained on the wire outlet grille pictured in Fig. 5 and the previous calibrating work done by the Society [3] on such grilles, it was decided to be unnecessary to calibrate the wire inlet grille of the class room tested in the Mechanical Engineering Building. A calibration factor of 1.00 was accordingly used.

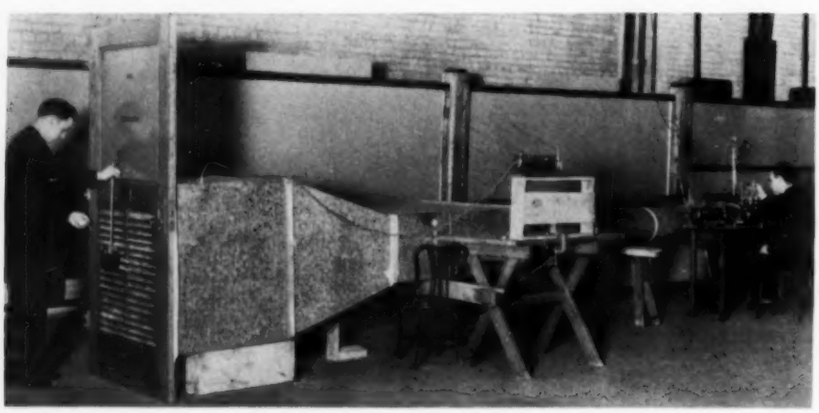

FIG. 6—CALIBRATION OF ANEMOMETER ON LOUVER DOOR

Results at Dudgeon School

A preliminary set of readings in the class room at Dudgeon School proved that sealing of all openings did not reduce the capacity of the unit ventilator materially. It was decided to seal the cracks in the mullion spaces before taking further readings. An attempt was also made to seal plaster cracks in the ceiling that would allow air to enter the attic space and to seal cracks in a side wall that allowed air passage to an adjoining toilet room.

[3] See Measurement of Flow of Air Through Registers and Grilles, by L. E. Davies (*Heating, Piping and Air Conditioning*, January 1930 and April 1931).

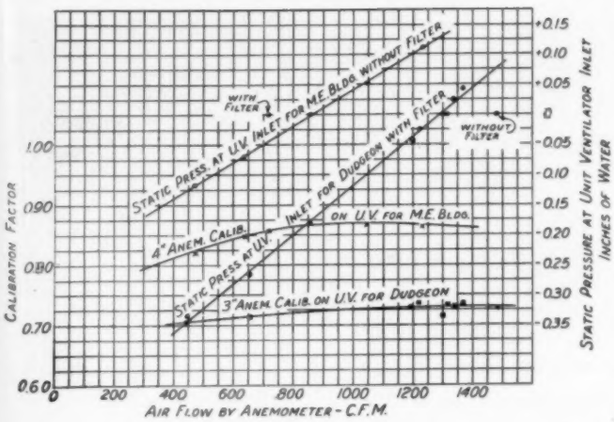
WITH FILTER
WITHOUT FILTER
STATIC PRESS. AT U.V. INLET FOR M.E. BLDG. WITHOUT FILTER
STATIC PRESS. AT U.V. INLET FOR DUDGEON WITH FILTER
4" ANEM. CALIB. ON U.V. FOR M.E. BLDG.
3" ANEM. CALIB. ON U.V. FOR DUDGEON
CALIBRATION FACTOR
STATIC PRESSURE AT UNIT VENTILATOR INLET INCHES OF WATER
AIR FLOW BY ANEMOMETER - C.F.M.

FIG. 7—CALIBRATION FACTORS FOR ANEMOMETERS ON UNIT VENTILATOR GRILLES

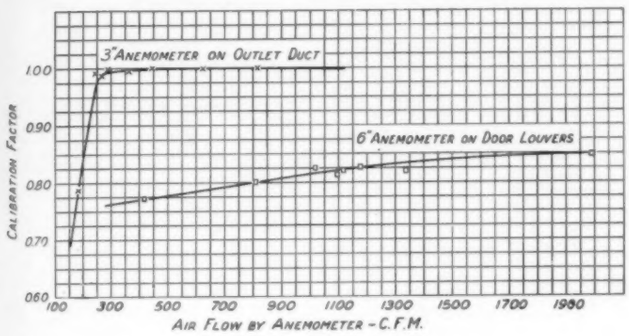

FIG. 8—CALIBRATION FACTORS FOR ANEMOMETERS ON OUTLET VENTS

One of the series of tests made after this preliminary sealing of unusual exits for air is shown in Fig. 9. The speed and the unit ventilator output were varied over the range provided by the allowable voltage variation at the motor-generator set. This range was from 87 volts to 137 volts. Normal voltage was 125 volts. Two sets of tests were made, one with the outlet duct open and another with it completely sealed. The results for each determine practically a straight line variation between voltage and air delivery. At the lowest air delivery the influence of the outlet duct is shown to be 63 cfm. This increased to about 72 cfm at the maximum output. In relation to the capacity with the outlet vent open the capacity with the outlet vent sealed was about 90 to 92 per cent. The capacity at normal voltage was 792 cfm without the outlet vent. The values obtained in some other tests at normal voltage of this same unit were 820 cfm and 755 cfm, respectively. The filter which was thoroughly cleaned was kept in place during all observations. The calibration tests on a similar unit in the laboratory showed 14 per cent greater capacity with the filters removed than with them in place. The unit used for calibration in the laboratory was operated by alternating current, otherwise the two units were identical. The capacity obtained with the laboratory unit at zero static pressure with the filter installed was 950 cfm as compared to 820 cfm for the unit tested at Dudgeon School.

In a series of tests at Dudgeon when 820 cfm was supplied by the unit ventilator, 55 per cent left the room by way of the planned outlet vent. When this outlet vent was sealed, the air supplied by the unit ventilator was reduced to 758 cfm or 92 per cent of normal capacity. Sealing the sash perimeters of the windows reduced the capacity to 700 cfm or 85 per cent of normal capacity. The additional sealing of the door and transom perimeters reduced the air volume supplied by the unit ventilator to 590 cfm or 72 per cent of normal capacity. This amount of air was finding its way out of the room through various small openings such as plaster cracks, under the baseboard, around steam pipes, through the floor and around the door and window frames. The recirculating openings, steam and return connection openings and all joints were sealed in the unit ventilator to prevent the measurement of recirculated air.

Observations at the Mechanical Engineering Building

Similar series of tests were conducted in a typical class room of the new Mechanical Engineering Building. The class rooms are ventilated by a central fan system. A unit ventilator, however, was installed and the central fan inlet sealed for a series of tests. This unit was equipped with a rheostat so that a speed variation was possible. Two sets of tests mere made at different motor speeds, one with the central fan running, so that air was being supplied to adjoining class rooms and the corridor as under normal operation, and another series with the central fan shut off. The difference in the two shows the effect on the unit ventilator of the pressure exerted in the corridor and adjoining class rooms by the central fan. The outlet vent area is large and leads directly from the corridors to the roof so that the pressure in the corridor was about one-half that in Dudgeon School.

The results of tests of the class room when equipped with a unit ventilator are shown in Fig. 10. The abscissa used is the area involved in escape of air from the room. The distance *A* to *B* represents the 5.13 sq ft of area of the louver opening in the door; the distance *B* to *C* represents the crack under and around the door perimeter; and the distance *C* to *D* represents the approximate area of the window sash perimeter crack.

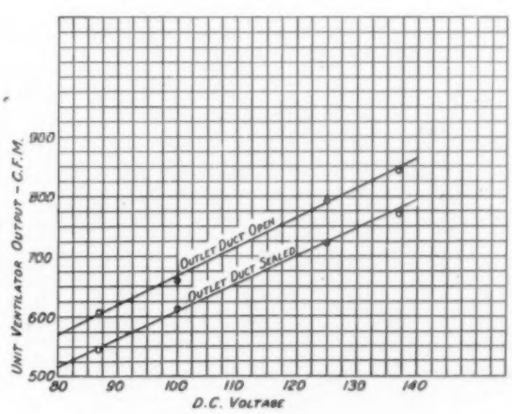

FIG. 9—DUDGEON UNIT VENTILATOR OUTPUT

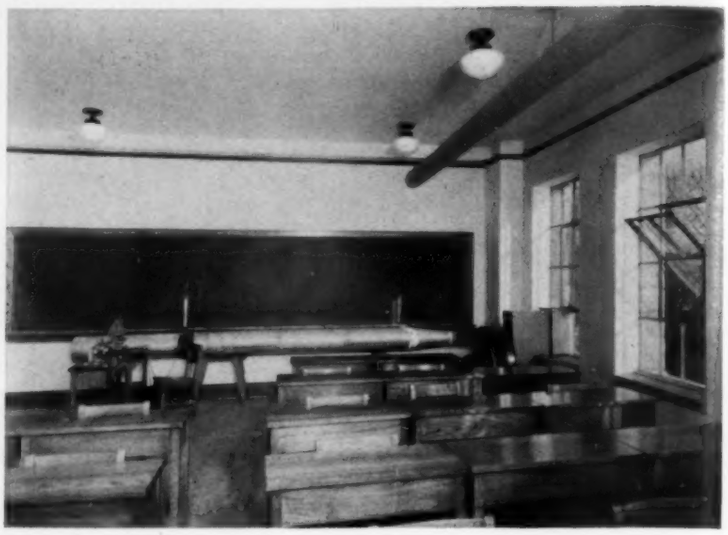

FIG. 11—MOTOR-BLOWER ARRANGEMENT IN MECHANICAL ENGINEERING BUILDING CLASS ROOM

The points at *A* with none of the outlet openings sealed show that at every motor speed there was less air delivery with the central fan on than with the fan off. In every case but one, the difference in the air passing through the louvers accounted largely for the reduced air delivery. This difference as measured at the unit ventilator grille ranged from 28 cfm at the highest delivery to 88 cfm at the lowest motor speed and air delivery. In per cent of the deliveries with the central fan off these would be 4 per cent and 17.5 per cent. The average reduction due to the effect of the central fan was 64 cfm. With the louvers sealed the average effect was reduced to 41 cfm. With further sealing, such as sealing the ½-in. crack beneath the door, the difference became very small as shown at *C* and *D*.

The maximum air delivery secured with the unit ventilator installation averaged 728 cfm. On the calibration runs in the laboratory on this same unit ventilator, 744 cfm was secured at a zero static inlet pressure. This decrease in capacity was probably due to the building up of pressure in the room and to the resistance offered by the special inlet duct required so as to bring the air in through the bottom row of window panes.

Upon sealing the louvers the air delivery of the unit ventilator was reduced from 728 cfm to 552 cfm or a 24 per cent reduction. Additional sealing of the door perimeter reduced the air delivery to 466 cfm, which is 64 per cent of the normal delivery. Further sealing of the window sash perimeters reduced the air delivered by the unit ventilator to 346 cfm, a reduction to 47.5 per cent of the normal delivery.

The slope of the lines from *B* to *C* and *C* to *D* seem to indicate that they would meet if extended downward approximately when the air flow into the room would be zero at 0.9 sq ft to the right of line *D*. This would indicate very roughly that the various minute openings for escape of air from the room had a total area less than one square foot. An inspection of the room makes it seem improbable that the openings remaining after sealing the louvers, the door perimeter and the window sash perimeters would total more than the perimeter of the windows. No plaster cracks were noticeable. The windows are set in such a way that frame leakage would seem to be negligibly small. The plastering extends to the concrete sub-floor quite uniformly. The steam pipe openings where an overhead main goes through two tile partition walls, where the steam supply branch comes through a tile partition and where the return connection passes through the floor to the laboratory space below would seem to be the main avenues of exit. During the runs while the central fan was in operation, the pressure in adjoining class rooms would oppose at least partially the passage of air around the steam pipes into these rooms. However, it would still be possible for air to enter the hollow tile in these partitions and reach the attic space. It appears unlikely that the area of these minute openings would total over 0.3 sq ft which is the area estimated for the window crack perimeter. Figs. 3 and 11 show some of the construction details of the room.

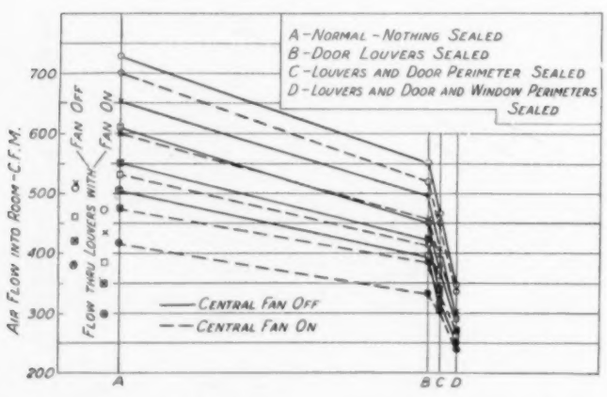

FIG. 10—UNIT VENTILATOR OUTPUT AT MECHANICAL ENGINEERING BUILDING UNDER DIFFERENT OUTLET CONDITIONS

To be Concluded in the July Issue

Loss of Head in Copper Pipe and Fittings

By F. E. Giesecke[1] (*MEMBER*) and W. H. Badgett[2] (*NON-MEMBER*)
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This paper is the result of research conducted at the A. & M. College of Texas in co-operation with the A. S. H. V. E. Research Laboratory and the Associated Copper Tubing Manufacturers

THE purpose of this investigation was to determine the losses of head in copper pipe and fittings. Tests were conducted on ¾-in., 1-in., 1¼-in. and 1½-in. copper pipe, joined with couplings modified and installed as described in the following paragraphs, ¾-in., 1-in., 1¼-in. and 1½-in. copper elbows, and 1-in. copper tees. The water was maintained at a mean temperature of 84 F for all tests, varying not more than 1 deg from that mean. The room air temperature varied not more than 4 deg from that of the water.

Description of Apparatus and Procedure

The set-up used in these experiments is shown in Figs. 1, 2, 3 and 4. It consists essentially of an apparatus for securing a constant water temperature and a constant pressure head, a pipe line containing the pipes and fittings to be tested, and devices for measuring the velocity of the water in the pipes and the corresponding losses of head.

The water supplied for these tests came from the College mains and varied in temperature from time to time. To eliminate this variation, a heating device was constructed by means of which it was possible to control the temperature of the water within one degree of an established mean. This device consisted of a pipe coil, through which the water passed, immersed in a steam bath. By means of valves, a portion of the water was passed through this coil and raised to a higher temperature and then mixed in the proper proportion with the water coming directly from the mains so as to secure water of the desired temperature to be used in the tests.

Since the studies were conducted during the summer months when the water taken from the College mains had a temperature ranging from 70 F to 80 F, it was deemed advisable to use a mean temperature above 80 F in order to facilitate temperature control, and a mean temperature of 84 F was selected and maintained throughout the tests.

From the heating coil, the water passed into an elevated supply tank in which a constant head was maintained by means of an overflow pipe. From this supply tank the water flowed by gravity through a connecting pipe line into the pipes and fittings to be tested, and from there into a weighing tank. The rate of flow was controlled by means of gate valves placed on each side of the pipe and fittings tested.

FIG. 1—DETERMINATION OF THE LOSS OF HEAD IN COPPER PIPE

The velocities were determined by weighing the discharge in tanks placed on a set of scales. By means of a stop watch, the time required for a predetermined quantity of water to be discharged was measured. The internal diameters of the pipes were obtained by means of calipers, and the results found to check within 0.001 in. with the factory rated diameters.

Loss of head was measured by means of piezometer rings placed at the beginning and end of the test sections and connected, by means of ¼ in. pipe and rubber tubing, to vertical manometer tubes. The three manometer tubes used had equal degrees of capillary action. The manometer scales could be read directly to the nearest millimeter, and, by interpolation, more accurately.

Pipe Tests

For each size of pipe tested, 40 ft of pipe were set up with piezometer rings placed 5 ft from each end, making the length of each test section 30 ft. This pipe line consisted of four pipes 10 ft long and three couplings from which the separating projection had been removed in order that the two adjacent pipes were in direct contact with each other. (See Figs. 1 and 2.) Before assembling the four sections of pipe, the inside of each end was sandpapered to remove any possible burr and the ends were placed tightly against each other. Extreme care was exercised in making the connections to elim-

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For presentation at the Semi-Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Milwaukee, Wis., June, 1932.

inate the possibility of solder running through the joint to the inside of the pipe. Sections were taken apart for examination to make certain that none had entered. A series of velocities was used on each size of pipe tested, and the results are shown in Fig. 5.

Elbows

After all laboratory tests were satisfactorily completed on the copper pipe, tests were made on the elbows. The couplings joining the 10-ft lengths of pipe were removed, the pipe ends carefully cleaned, and the couplings replaced by elbows as shown in Fig. 3. The set-up for each size of elbow consisted of 40 ft of pipe and four elbows connected in series as shown in the diagram.

The velocity of the water flowing in the pipe and the corresponding loss of head in the 40 ft of pipe and the four elbows were then determined for a series of velocities. From these values the losses of head in 40 ft of pipe were deducted and the remainder divided by four to determine the loss of head in one copper elbow. The data for these tests are shown in Figs. 6, 7, 8 and 9. The results for the four sizes of elbows are shown collectively in Fig. 10.

Tees

The apparatus and procedure for determining the loss of head in the tees were the same as for determining the loss of head in cast-iron tees, described in the papers, Friction Heads in One-Inch Standard Cast-Iron Tees, and Supplementary Friction Heads in One-Inch Cast-Iron Tees[3]. Two set-ups were used, one with the water

[3] Friction Heads in One-Inch Standard Cast-Iron Tees, by F. E. Giesecke and W. H. Badgett (*Heating, Piping and Air Conditioning*, May, 1931, pp. 430-432), and Supplementary Friction Heads in One-Inch Cast-Iron Tees, by F. E. Giesecke and W. H. Badgett (*Heating, Piping and Air Conditioning, January*, 1932, pp. 53-56).

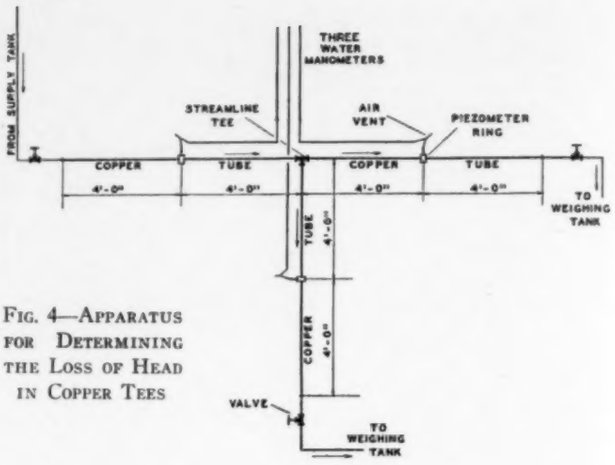


FIG. 4—APPARATUS FOR DETERMINING THE LOSS OF HEAD IN COPPER TEES

entering an end branch of the tee and a part of the water flowing out the side branch with the remainder continuing straight through the tee (Fig. 4). The data for these results are shown in Fig. 11. In the other set-up (Fig. 12), the water entered the middle branch of the tee and flowed out the two end branches. The data for the results in this case are given in Fig. 12.

When the water flows through the tee, as shown in the illustration of Fig. 11, and 70 per cent of the water entering at *A* is diverted through the outlet *C*, the loss of head in the portion so diverted is equivalent to the loss of head which would result if the water had flowed through two elbows instead of through the tee. Similarly, if 50 per cent is diverted, the loss of head is four elbow equivalents, as shown by the curve of Fig. 11.

When the water is flowing through the tee as shown by the illustration in Fig. 12 and 70 per cent of the water entering at *C* is diverted through the outlet *A*, the

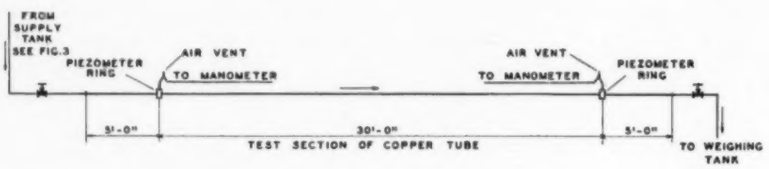


FIG. 2—APPARATUS FOR DETERMINING THE LOSS OF HEAD IN COPPER PIPE

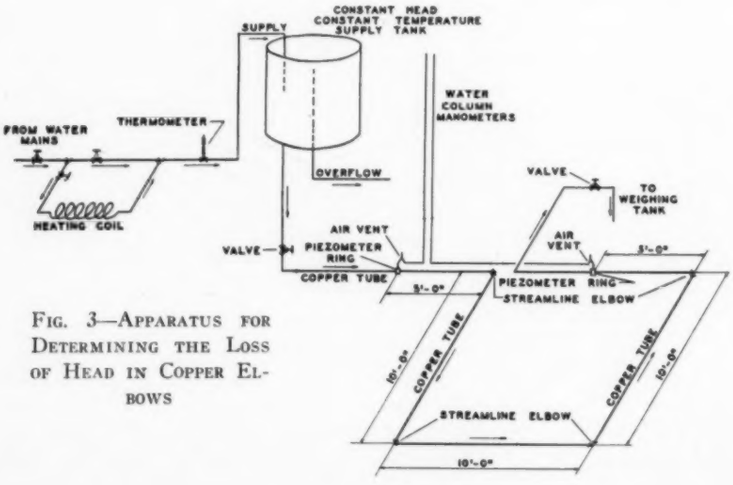


FIG. 3—APPARATUS FOR DETERMINING THE LOSS OF HEAD IN COPPER ELBOWS

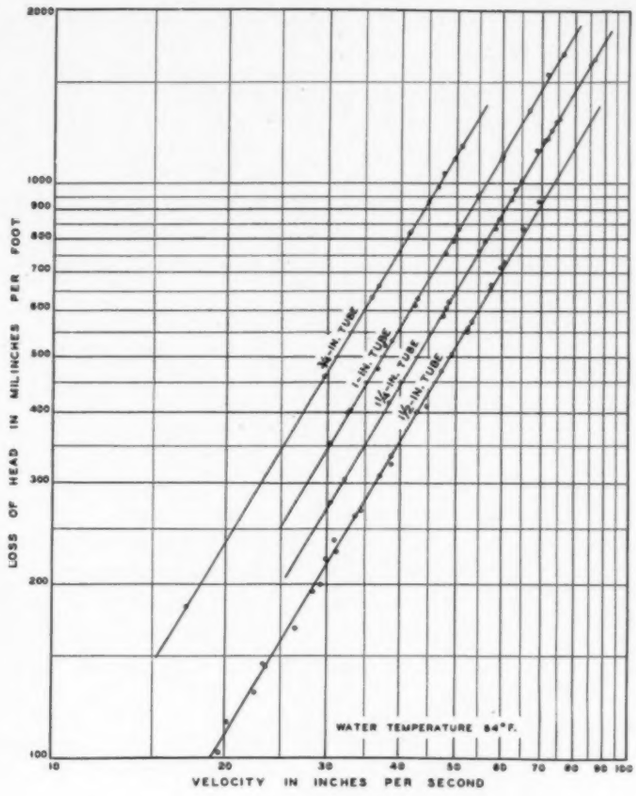


FIG. 5—THE LOSS OF HEAD IN COPPER PIPE

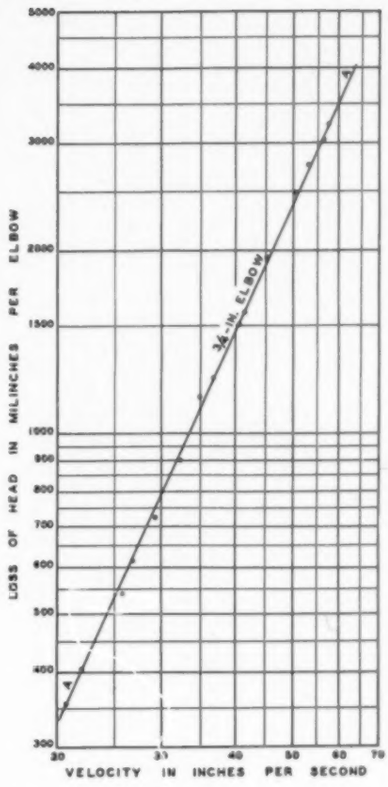


FIG. 6—THE LOSS OF HEAD IN ¾-IN. COPPER ELBOWS

loss of head in the portion so diverted is three elbow equivalents. In this case, 30 per cent is diverted through the outlet *B* and the loss of head in that portion is about 16 elbow equivalents, as shown by the curve of Fig. 12.

The loss of head in one elbow, *i.e.*, an elbow equivalent, as used in Figs. 11 and 12, is equal to $\frac{0.7v^2}{2g}$.

Conclusions

The loss of head in copper pipe for 84 F water may be expressed by the formula:

$$h = 1.16\frac{v^{1.7}}{d^{1.22}} \qquad (1)$$

where

h = the loss of head in milinches of water per foot of pipe

v = the velocity of the water flowing in the pipe in *inches* per second, and

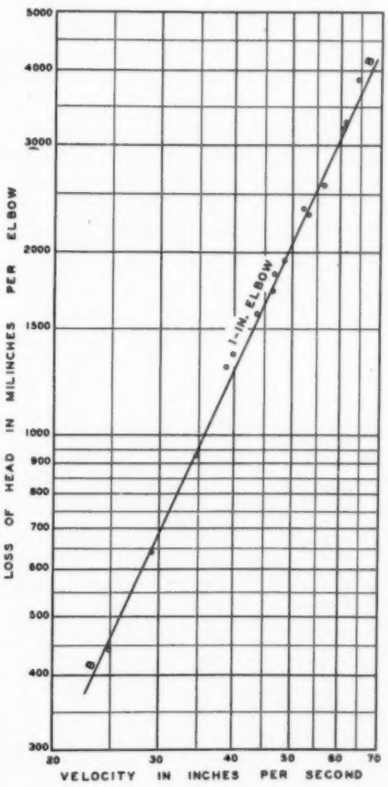


FIG. 7—THE LOSS OF HEAD IN 1-IN. COPPER ELBOWS

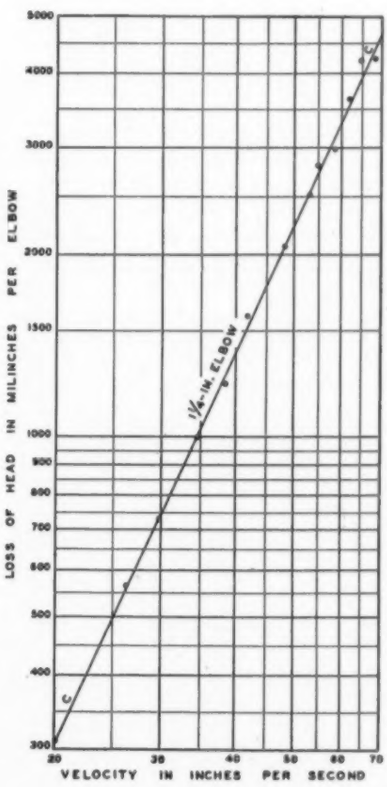


FIG. 8—THE LOSS OF HEAD IN 1¼-IN. COPPER ELBOWS

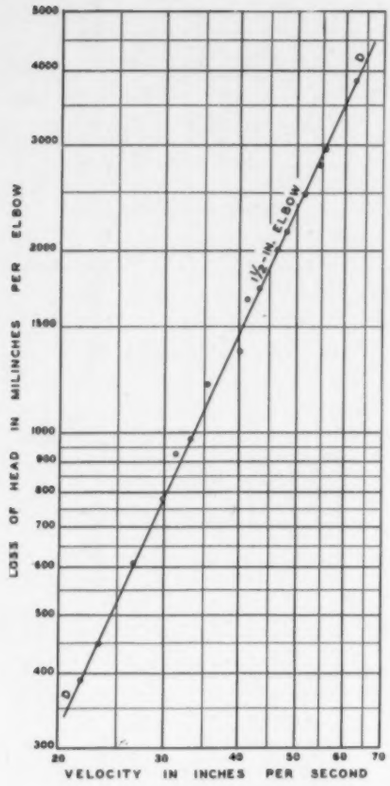


FIG. 9—THE LOSS OF HEAD IN 1½-IN. COPPER ELBOWS

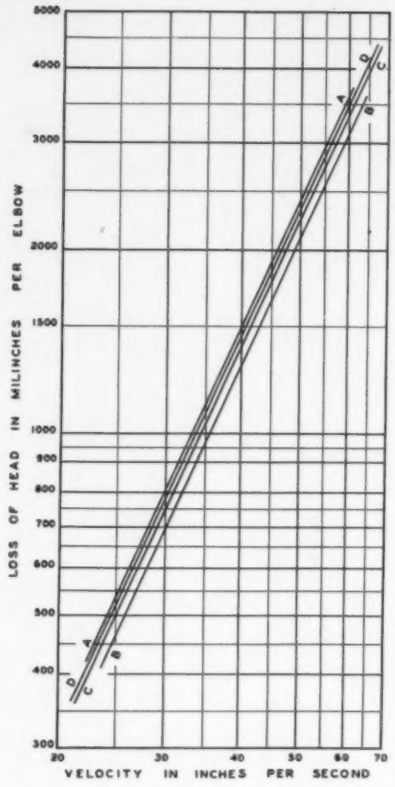


FIG. 10—THE LOSS OF HEAD IN COPPER ELBOWS, FOR THE FOUR SIZES TESTED, SHOWN COLLECTIVELY

d = the actual inside diameter of the pipe in inches, and varies from ¾ in. to 1½ in.

The loss of head in a copper elbow may be expressed, approximately, by the formula

$$h = 0.7\frac{v^2}{2g} \qquad (2)$$

where

h = the loss of head in milinches of water
v = the velocity, in inches per second, of the water in the pipe fitting the elbow
g = the acceleration due to gravity (386 in. per second each second)

The loss of head in a copper tee may be expressed, approximately, by the formula

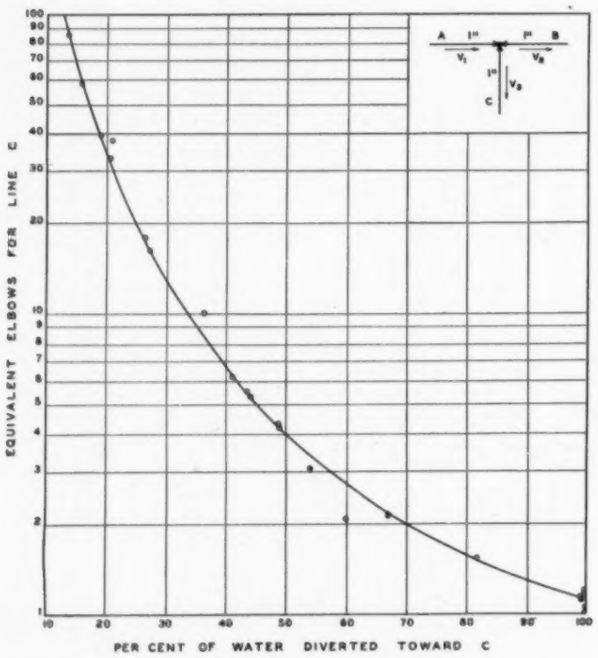


FIG. 11—THE LOSS OF HEAD IN 1-IN. COPPER TEES WHEN WATER ENTERS AT *A* AND A PORTION IS DISCHARGED AT *C*, IN TERMS OF THE FRICTION HEAD OF AN ELBOW AT *C*

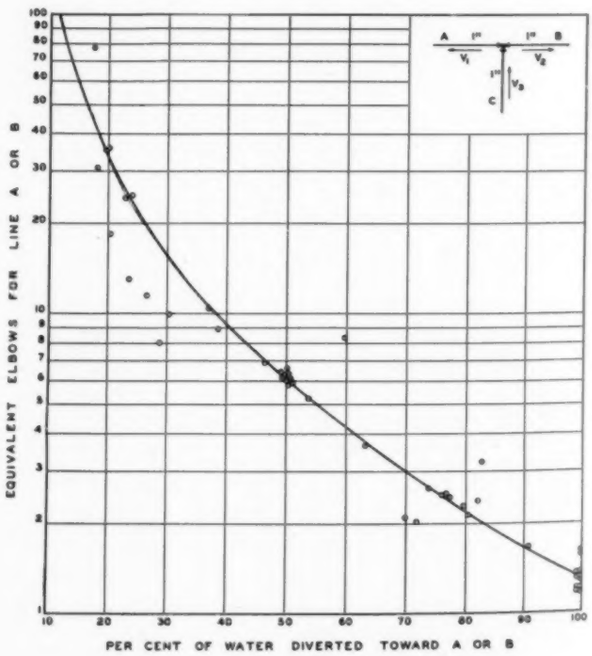


FIG. 12—THE LOSS OF HEAD IN 1-IN. COPPER TEES WHEN WATER ENTERS AT *C* AND IS DISCHARGED AT *A* AND *B*, IN TERMS OF THE FRICTION HEAD OF AN ELBOW AT *A* OR *B*

$$N_e = \frac{0.7\,(v_1^2 + v_3^2)}{v_3^2} \qquad (3)$$

where (for the case shown in Fig. 11)

N_e = the number of elbows which would cause the same loss of head as the tee when the velocity of the water in the connecting pipe is v_3

v_1 = the velocity of the water in the pipe entering the tee

v_2 = the velocity of the water in the pipe discharging from the tee at right angles to v_1

For the case shown in Fig. 12, the loss of head can be expressed, approximately, by the formula

$$N_e = \frac{v_2^2 + v_1^2}{v_1^2} \text{ or } \frac{v_3^2 + v_2^2}{v_2^2} \qquad (4)$$

Effect of Variation in Water Temperature

The loss of head in pipes varies with the temperature of the water because the temperature affects the viscosity, the viscosity affects the internal friction, and the internal friction is largely the cause of the loss of head in pipes. The method of determining the effect of temperature on the loss of head in pipes is described in a paper entitled, Effect of Temperature Upon the Friction of Water in Pipes, by F. E. Giesecke[4], presented at the 31st Annual Meeting of the American Society of Heating and Ventilating Engineers, Boston, Mass., January, 1925. For a velocity of 3 fps and a 1¼-in. pipe, the loss of head will be increased about 5 per cent if the temperature of the water is lowered from 84 F to 70 F.

The loss of head in elbows and tees is caused largely by the loss of kinetic energy resulting from the change in the direction of the flow of water and, for that reason, is practically independent of ordinary changes in the temperature of the water.

APPENDIX

Comparison of Copper Pipe and Fittings with Iron Pipe and Fittings

To compare the losses of head in copper pipe with those in iron pipe of the same nominal diameter, the diagram of Fig. 13 was prepared by using the values for copper pipe determined in this investigation and the values for new clean iron pipe calculated by the formula[5]

[4] See A. S. H. V. E. Transactions, Vol 31, 1925.

[5] See *University of Texas Bulletin No.* 1759, p. 3.

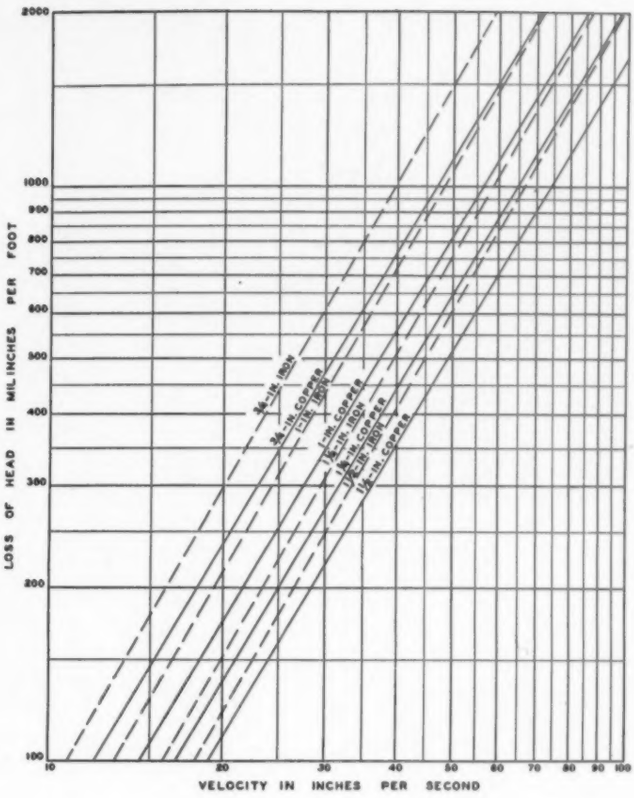


Fig. 13—Loss of Head in Various Sizes of Iron and Copper Pipe

$$h = 0.00685\,\frac{v^{1.77}}{d^{1.273}} \qquad (5)$$

The loss of head in a standard cast-iron elbow is practically equal to $\frac{v^2}{2g}$; the loss of head in a copper elbow is about $0.7\frac{v^2}{2g}$, provided the internal diameter of the elbow is equal to that of the pipe connected to it and provided the two are joined so that there is no sudden enlargement or contraction in the channel through which this water flows, as was the case with the elbow and pipe tested in this investigation.

Correction Factor for Radiators and Gravity Convectors

The A. S. H. V. E. Standard Code for Testing and Rating Concealed Gravity Type Radiation (Steam Code) provides for rating tests to be run in a warm wall booth of specified construction and dimensions, with a temperature of 215 F for the steam in the heating unit and a temperature of 65 F for the air at the inlet to the enclosure. It further provides that convectors should be tested with the temperature of the air at the inlet between 60 F and 80 F. For tests run with inlet air temperatures other than 65 F, but conforming with these limiting temperatures, the heat output obtained by test is to be reduced to a standard heat output by multiplying the actual heat output by the following correction factor:

$$C = \left[\ \frac{150}{t_s - t_i}\ \right]^{2.8}$$

where

150 = the standard temperature difference between steam at 215 F and inlet air at 65 F

t_s = the temperature of steam during the test, degrees Fahrenheit

t_i = the inlet air temperature during the test, degrees Fahrenheit

This correction factor is the one commonly used in the case of direct cast-iron radiators.

THE COURT OF HONOR, SHOWING THE WASHINGTON MONUMENT IN THE FOREGROUND

Meet Me in Milwaukee!!

THIS is the slogan of Society members, who are now making plans to attend the Semi-Annual Meeting 1932, which opens at the Hotel Pfister, Milwaukee, Wis., June 27. With the Wisconsin members as hosts, three wonderful days are in prospect for the members and ladies will find plenty on the program to occupy their time and make the trip worthwhile.

The schedule of events arranged by General Chairman John S. Jung and his Committee will commence at 8:30 a. m. Monday with registration at the Hotel Pfister. John Shodron of Ft. Atkinson and his Reception Committee will be on hand to greet the visitors and Prof. G. L. Larson with his co-workers on the Registration Committee will see that each member and guest is provided with proper badge, program, information about the trips and golf tournament, ladies' entertainment, banquet and other functions. The ladies will be specially entertained and their program has been arranged by C. H. Randolph and Mrs. E. A. Jones with the assistance of the other Chapter ladies, who will act as hostesses.

The opening session on Monday, June 27, will commence at 10:00 a. m. (Standard Time) and Pres. F. B. Rowley will preside. One of the most important subjects of discussion at the first session will be the Report of the Committee of Revision of the Constitution and By-Laws to be presented by Chairman W. T. Jones. Copies of the report are to be printed and furnished to members in advance of the meeting, in order that the proposed revisions may be properly discussed at the meeting. The Committee has incorporated in the new regulations, various suggestions received from members and are presented in three major divisions—(1) Constitution; (2) By-Laws and (3) Rules, in order that the procedure for handling all Society functions may be simplified for more effective operation.

Two technical papers are to be presented Monday morning, one on Velocity Characteristics of Hoods under Suction by J. M. Dallavalle, Consulting Engineer, Cleveland, Ohio, and the other, resulting from studies made by the A. S. H. V. E. Research Staff in Pittsburgh, the subject being Natural Wind Velocity Gradients Near a Wall by J. L. Blackshaw and F. C. Houghten.

An important contribution has been made in the report of the Technical Advisory Committee which studied the Comfort Chart and Comfort Line, so that engineers will know how to use the effective temperature index and comfort charts. This committee consisted of C. P. Yaglou, Chairman, W. H. Carrier, Dr. E. V. Hill, F. C. Houghten and J. H. Walker.

Two research papers, one giving the results of a survey of ventilation conditions in a ramp garage by members of the A. S. H. V. E. Research Staff and the other reporting some cooperative research investigations at the University of Wisconsin on air outlets for school room ventilation, will be of exceptional interest to engineers, who must design systems to provide desirable air quality and quantity.

THE WISCONSIN AVENUE BRIDGE IS SHOWN HERE AS IT OPENS TO PERMIT THE PASSAGE OF A PASSENGER BOAT

G. L. Larson
Registration

Ernest Szekely
Publicity

E. A. Jones
Golf

F. G. Weimer
Banquet

John S. Jung
General Chairman

Prof. F. B. Rowley
President of the Society

W. H. Wilson
Vice-Chairman

H. F. Haupt
Entertainment

V. A. Berghoefer
Finance

C. H. Randolph
Ladies Entertainment

Mrs. E. A. Jones
Hostess

ROOM RATES AT THE NEW PFISTER

Double

Twin Beds and Bath.....$6, $7, $8 and $10 per day
Double Bed and Bath.....$5, $6 and $8 per day
Double Bed, Lavatory and Toilet.....$5, $6 per day

Single

Single Room and Bath.....$3.50, $4, $5 and $6 per day
Single Room, Lavatory and Toilet.....$3.00 per day

AUTO MILEAGE TO MILWAUKEE

City	Auto Miles	City	Auto Miles
Boston	1090	Los Angeles	2287
Buffalo	631	Minneapolis	372
Chicago	93	New York	958
Cincinnati	392	Philadelphia	861
Cleveland	441	Pittsburgh	568
Detroit	371	St. Louis	398
Grand Rapids*	232	Seattle	2178
Kansas City	603		

*Via Chicago

RAILROAD AND PULLMAN RATES

	Fare and One-Half	Pullman Lower Berth
Boston, Mass.	$ 59.54	$10.88
New York, N. Y.	53.64	9.75
Philadelphia, Pa.	48.78	9.00
Pittsburgh, Pa.	29.91	5.25
Cleveland, Ohio	22.98	4.50
Detroit, Mich.	20.33	4.50
Chicago, Ill.	4.59	.75 (seat)
St. Louis, Mo.	20.21	4.50
Seattle, Wash.	111.92 (direct)	23.63
Seattle, Wash.	115.82 (via Chicago)	24.38
Los Angeles, Calif.	122.88	24.38
Grand Rapids, Mich.	15.81	3.75
Minneapolis, Minn.	17.31	3.75
St. Paul, Minn.	17.31	3.75
Cincinnati, Ohio	19.98	4.50
Kansas City, Mo.	27.99	4.50
Buffalo, N. Y.	32.81	6.38
Toronto, Can.	38.31	6.38

The Committee on Ventilation Standards has prepared a report to be given by Chairman W. H. Driscoll and advance copies are to be furnished to members so that this important matter, previously discussed at the Annual Meeting in Cleveland, may be considered in greater detail.

On Wednesday, four papers have been scheduled and each of the subjects treated is of outstanding interest at present, three of them originating in the laboratories of universities cooperating with the Society's Research Laboratory.

The aim of the Arrangements Committee has been to plan a program that would be attractive and entertaining and at the same time be in step with the times. In accordance with the

Method of Choosing Location of, Financing and Conducting Meetings of the Society

Resolved: That inasmuch as the Annual and Semi-Annual Meetings of the Society come under the jurisdiction of the Council, the following rules governing the handling of such meetings be adopted by the Council and published in the JOURNAL of the Society at least twice during every year, preferably just prior to each meeting:

1—The Council will select the city in which the Annual or Semi-Annual Meeting is to be held, giving due consideration to the invitations received from Chapters or members as well as to the advisability of so distributing those meetings as to make them of the greatest advantage to the general membership, and to reduce as far as possible the expense of members attending.

2—That an appropriation be made to cover the entertainment or local expenses, incurred in connection with the meeting not exceeding $500.00, the regular meeting expense to be taken care of by the General Fund of the Society in the regular way.

3—That no registration fee or compulsory obligations of any nature be imposed on members or guests.

4—That the purchase of tickets for banquets or for any other form of entertainment that may be provided be entirely voluntary.

5—That the grouping of features and the same of tickets for group features be discouraged.

6—That the raising of Funds from manufacturers of heating apparatus be discouraged.

7—That the display of samples, or of literature, advertising the product of any manufacturer in any way, shape or form, be not permitted at the booths, registration desk, or in or about the meetings.

8—That the distribution of trade papers be entirely at the discretion of the committee in charge.

9—That the local Chapter, or local members, be empowered to form a General Committee with such sub-committees as may be required to handle the details of transportation, hotel accommodations, entertainment, finance, etc., and that this General Committee be requested to confer frequently with the Council, through the Secretary of the Society, and to make frequent reports on progress in connection with the various matters being handled by them.

10—That the arrangements of elaborate and costly entertainment features be discouraged.

Adopted at Council Meeting, January 29, 1926.

An Air View of Downtown Milwaukee Showing the Industrial and Shopping District

PROGRAM

SEMI-ANNUAL MEETING 1932

American Society of Heating and Ventilating Engineers

June 27, 28 and 29

Hotel Pfister Milwaukee

(All events on Central Standard Time)

Monday, June 27

8:30 A. M.—Registration, Hotel Pfister (7th Floor)

10:00 A. M.—Technical Session (Fern Room)

Greeting—E. A. Jones, President, Wisconsin Chapter

Response—Pres. F. B. Rowley

Report of the Council

Paper—

Velocity Characteristics of Hoods Under Suction, by J. M. Dallavalle

Paper—

Natural Wind Velocity Gradients Near a Wall, by J. L. Blackshaw and F. C. Houghten

Report—

Committee on Revision of Constitution and By-Laws—W. T. Jones, Chairman

12:00 M. —Ladies leave Hotel Pfister for Luncheon and Bridge at Milwaukee Yacht Club

12:30 P. M.—Golfers leave Hotel Pfister for Luncheon at Ozaukee Country Club

1:30 P. M.—Tournament (Research Cup)—18 Holes Medal Play

2:30 P. M.—Visit to A. O. Smith Laboratories

6:30 P. M.—Committee on Research—Dinner-Meeting

8:30 P. M.—Entertainment, Dance, Dutch Lunch (9th floor Wisteria Room)

Tuesday, June 28

9:30 A. M.—Technical Session (Fern Room)

Report—

How to Use the Effective Temperature Index and Comfort Charts (Report of Technical Advisory Committee on Re-Study of Comfort Chart and Comfort Line, C. P. Yaglou, Chairman)

Paper—

Carbon Monoxide Distribution in Relation to Garage Ventilation, by F. C. Houghten and Paul McDermott

Paper—

Investigation of Air Outlets in Classroom Ventilation, by G. L. Larson, D. W. Nelson and R. W. Kubasta

Report—

Committee on Ventilation Standards—W. H. Driscoll, Chairman

10:30 A. M.—Ladies Auto Trip and Luncheon (Lake Shore, Parks, Conservatory, Sunken Gardens, Zoo)

12:30 P. M.—Luncheon Nominating Committee—H. M. Hart, Chairman

12:30 P. M.—Cars leave hotel for Luncheon and Golf at North Hills Country Club

2:30 P. M.—Inspection of Industrial Plants

7:30 P. M.—Semi-Annual Banquet and Dance (Fern Room, Hotel Pfister)

Wednesday, June 29

9:30 A. M.—Technical Session

Report—

Chapter Relations Committee—E. K. Campbell, Chairman

Paper—

Thermal Properties of Building Materials, by F. B. Rowley and A. B. Algren

Paper—

Tests of Convector Heaters in the Warm Wall Booth, by M. K. Fahnestock and E. L. Broderick

Paper—

Loss of Head in Copper Pipe and Fittings, by F. E. Giesecke and W. H. Badgett

Paper—

Automatic Gas Burners, by C. G. Segeler

Adjournment

10:30 A. M.—Ladies Choice—Golf, Museum, Beaches or Inspection of Pfister Art Gallery and Period Rooms.

Committee of Arrangements

John S. Jung, General Chairman

H. W. Ellis, Advisory
J. G. Shodron, Reception
G. L. Larson, Registration
A. M. Wagner, Transportation
V. A. Berghoefer, Finance
E. A. Jones, Golf
F. G. Weimer, Banquet
Ernest Szekely, Publicity
C. H. Randolph, Ladies Entertainment
H. F. Haupt, Entertainment
Mrs. E. A. Jones, Hostess

Officers Wisconsin Chapter

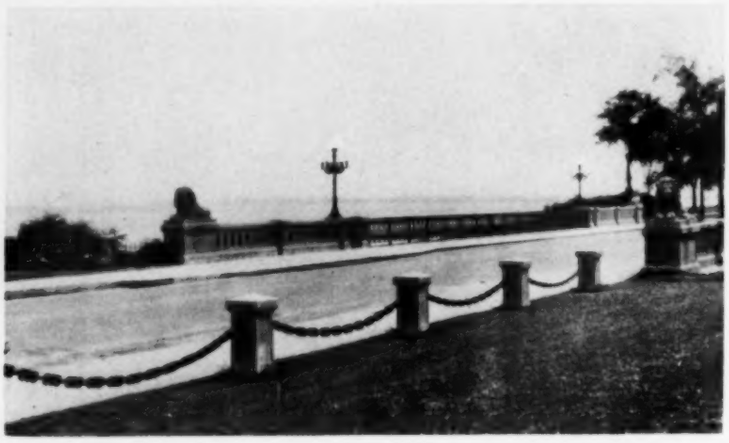
President, E. A. Jones
Secretary, H. F. Haupt
1st Vice Pres., V. A. Berghoefer
2nd Vice Pres., John S. Jung
Asst. Secy., A. F. Bowers
Treasurer, Martin Erickson

Board of Governors

G. L. Larson J. G. Shodron F. G. Weimer

time honored custom the Semi-Annual Banquet on Tuesday evening will be the featured social event. Ticket reservations should be made at the time of registration.

On Monday evening a Dutch lunch in the old Milwaukee manner will be served in the Wisteria Room where Tyrolean musicians will entertain between dances. A peppy orchestra will play for dancing at this party, which has been designated—A Night in Munich.



Driveway — A View of Lake Michigan as Seen From a Grassy Slope in Lake Park, Milwaukee

When the ladies go to the Milwaukee Yacht Club for luncheon and bridge on Monday afternoon, the golfers will be taken to the Ozaukee Country Club where luncheon is to be served and a golf tournament played for the Research Cup. Players will be taken by automobile to the Club and will have an opportunity to see the Lake Shore Boulevard and some of the fine residential sections of Milwaukee. Those who do not play golf may visit the A. O. Smith Laboratories or may join the crowd at the Golf Club for cards and other sports.

On Tuesday the special events for the ladies are a morning auto trip along the lake shore boulevard, through the city parks, and residential sections, ending with a luncheon at a downtown department store. The men have a choice of inspecting several of the well known industrial plants or playing golf.

Wednesday morning the ladies will have a choice of playing golf, taking a trip to the Museum or inspecting the Hotel Pfister art gallery and period rooms.

For those who travel by train, *reduced railroad fares* are available and Identification Certificates will be sent from the Headquarters Office to all members so that they may purchase round trip tickets at fare and one half. The return portion of the tickets is good for 30 days. Optional return routes are available at slightly higher rate. Combination tickets to northern and western points may be issued via Milwaukee if it is desired to make the trip as a part of a vacation tour. Chapter Officers are making plans for through car service and those who desire to ride in the Milwaukee Specials, should communicate with their Local Chapter Transportation Committee.

Research and Recognition

G. L. Larson, *Chairman*
Committee on Research

The Research Laboratory organization is in full swing in spite of financial handicaps that affect all in times like these. It is an inspiration to experience the *esprit de corps* which actuates every member of the Committee on Research, every member of its Technical Advisory Committees, and every member of the Research Finance Committee. The prestige of the Laboratory has gained to the extent that another large educational institution has offered to carry on cooperative research at no cost to the Society, furnishing necessary funds and equipment in exchange for coordination, direction, and publication of results.

It may not be generally appreciated by the Members at large that Carnegie Institute of Technology always has given to the work without direct financial return by the Laboratory. Announcement of a second arrangement of this type is a possibility in the near future.

Another favorable indication for the Laboratory is that through the efforts of one of the members of the Finance Committee, a great corporation has offered $1,500.00 for research in residence cooling and another big organization has pledged $1,000.00 for this same project.

These and other matters will be discussed in greater detail in this column from time to time.

Local Chapter Reports

Michigan

April 14, 1932. About 30 members and guests were present at the dinner meeting held at the Detroit Engineering Society, which was called to order by Pres. G. H. Giguere.

Tom Brown reported on the progress made for the May meeting at Meadowbrook Golf Course, and J. F. McIntire reported that the Council of the Society had accepted the invitation of the Michigan Chapter to hold its 1933 Semi-Annual Meeting in Detroit.

A. V. Hutchinson, Secretary of the Society, was introduced and spoke of the 1933 meeting and outlined the rules under which Society meetings are handled.

The principal speaker of the evening was Pres. F. B. Rowley, who is also Director of the Engineering Experimental Laboratories at the University of Minnesota. He gave a very interesting lecture entitled, Looking Forward in the Science of Heating and Ventilation, which he illustrated by slides.

The usual interesting discussion followed, after which a rising vote of thanks was extended to Professor Rowley.

Kansas City-St. Louis

April 16, 1932. History was made at Kansas City when the St. Louis Chapter came across the State of Missouri to join with the Kansas City Chapter in a co-operative meeting which was honored by the presence of Prof. A. C. Willard, technical adviser to the Committee on Research, past president of the Society and Professor of Mechanical Engineering at the University of Illinois, Urbana.

This marks an epoch in the activities of the Society and its success, it is believed, will lead to more activities of this nature. Pres. J. M. Foster of the St. Louis Chapter has already extended an invitation to the Kansas City Chapter for a return meeting, suggesting that it be a three cornered affair by including the Illinois Chapter. Professor Willard made a counter proposal that the three Chapters meet at Urbana, as guests of the University of Illinois.

About 65 members and guests were present at this joint meeting, including all of the officers and a number of the members of the St. Louis Chapter, among whom were Pres. J. M. Foster, C. A. Pickett, Paul Sodemann, A. L. Walters, W. C. B. Sodemann, E. E. Carlson, L. Walter Moon, G. A. Helwig and C. R. Davis. This visiting group contributed materially to the success of the venture.

The meeting was held at the Ambassador Hotel, where, after a splendid dinner and the usual introductions, Pres. J. M. Arthur of the Kansas City Chapter turned the meeting over to President Foster of the St. Louis Chapter.

The illustrated presentation by Professor Willard included the three major projects of investigation under way at the University at the present time. The first problem described was that of determining temperatures at various heights in a room when the room was heated by different types of direct and indirect heating units, with outside temperatures practically the same and with the radiators operating under the same room conditions. One angle of the problem under consideration was to determine the proper height above the floor level at which relative efficiencies of radiators should be tested. This is at present established at 30 in.

An extremely interesting part of the talk was that devoted to the investigation of methods and equipment suitable for ventilating the proposed Chicago Subway. The problems involved and the clever methods of working out solutions and in devising details of equipment made the work of great interest to everyone concerned with air movement and air conditioning.

The latter part of the lecture and a large part of the informal discussion centered upon the experiments to be started this summer on cooling the research residence at Urbana. After the completion of the very splendid talk by Professor Willard, he answered many questions by members and was given a rising vote of thanks.

It is the belief of those who attended that when the success of such cooperative meetings is generally known other Chapters will arrange to get together.

The idea which brought about this meeting was originated by E. K. Campbell, chairman of the Chapter Relations Committee of the Society, and a good part of the success of this meeting is due to his efforts.

Western Michigan

April 11, 1932. After the experience of seven of the out-of-town members returning home from the March meeting, in which they battled a blizzard half the night, it was rather expected that many would not leave their fireside for another meeting until blossom time. But loyalty and enthusiasm again asserted themselves at the April meeting with a record attendance of 52 members and guests.

Prof. F. B. Rowley, President of the Society, revealed new trends in his address entitled, Looking Forward in the Science of Heating and Ventilation. After a review of the progress of these sciences, he summarized the latest development in research and the accepted theories of the day. With stereopticon slides illustrating specimens and laboratory set-ups, Professor Rowley explained the results of his research on thermal conductivity of various assemblies of common building materials. A veritable bombardment of questions were answered by the speaker during the open discussion that followed.

The Chapter was also fortunate in having among the guests, A. V. Hutchinson, Secretary of the Society, who summarized the activities of the organization, and complimented the Chapter for having attained such an enthusiastic membership during the first year of its existence.

Pres. O. D. Marshall appointed a Program Committee for the Chapter's Spring Frolic, to be held in conjunction with its annual meeting.

Nominations were made for Officers and Board of Governors for the season 1932-33 as follows: D. L. Taze, *President;* K. L. Ziesse, *Vice-President;* S. H. Downs, *Treasurer;* P. O. Wierenga, *Secretary;* Cornelius Lammers, O. D. Marshall and C. H. Morton, *Board of Governors.* The meeting adjourned with a rising vote of thanks to the speakers.

Minnesota

May 9, 1932. The members of the Minnesota Chapter of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS assembled at the Golden Valley Golf Club for their May meeting.

Since this was the last meeting of the season 1931-32, an annual field day and election of officers for the year 1932-33 took place.

The golf scores made during the afternoon indicated that the Minnesota Chapter members will make a strong bid for the Research Cup at the Semi-Annual meeting to be held in Milwaukee, June 27 to 29, 1932.

Following the dinner, the meeting was called to order by Pres.

H. E. Gerrish, and the following officers were elected to serve for the coming year:

President—W. F. Uhl.
Vice-President—A. B. Algren.
Secretary-Treasurer—C. E. Lewis.
Board of Governors—H. E. Gerrish and C. E. Gausman.

April 11, 1932. Fifty-two members and guests assembled at the St. Paul Municipal Auditorium for the April meeting of the Minnesota Chapter, with Pres. H. E. Gerrish presiding.

Following the dinner which included some special features that added to the enjoyment of the evening, a short business meeting was held. President Gerrish, in welcoming members and guests, explained the absence of one of the honored members of the Chapter, Prof. F. B. Rowley, President of the Society. When considering his most recent visit to the following chapters, it is quite evident that his attendance at chapter meetings has the aspect of being national rather than local: Pittsburgh—April 11; Buffalo—April 12; Toronto—April 13; Detroit—April 14; Grand Rapids—April 15; Milwaukee—April 18.

President Gerrish then turned the meeting over to A. J. Huch, chairman of the Meetings Committee, who gave some of the high-lights of the May meeting, with emphasis on the golf meet.

C. E. Gausman and E. F. Jones, engineers on the design and laying out of the mechanical equipment of the Auditorium, were then introduced. Their talks covered the interesting features of the mechanical equipment, and it is quite evident that in the building of the Auditorium the primary object was to have complete facilities for a meeting place for large exhibits and conventions. The housing capacity of the Auditorium, taking into account all assembly rooms and committee rooms, is 48,000 persons.

Manager Murray, of the Auditorium, showed some motion pictures that he had taken, of which the most interesting feature was the arena that may be used either as a skating rink or for any other purpose which would require the removal of ice within a short period of time.

An inspection trip of the building was then made. The main points of interest were the heating and ventilating system, the refrigerating machinery with auxiliary equipment, and the projecting room containing the public address system.

Pittsburgh

April 11, 1932. The April meeting of the Pittsburgh Chapter was held in the Rose Room of the Fort Pitt Hotel, with 58 members and guests present when Pres. R. B. Stanger called the meeting to order.

Leo Green, president of the Pittsburgh Steam Fitters Union, spoke on the present practice of peddling bids in building construction, and was followed by A. V. Hutchinson, Secretary of the Society, who talked on Society activities. It was announced that F. C. McIntosh had been appointed by the Council to serve as a member of the Society's Committee on Research.

Secretary Blackshaw introduced Prof. F. B. Rowley, President of the Society and Director of the Experimental Engineering Laboratories at the University of Minnesota, who spoke on Looking Forward in the Science of Heating and Ventilation.

Professor Rowley traced the progress of heating and ventilation from first developments to the present time, telling of the research work which is being carried on throughout the country, especially that of the Society's Research Laboratory under Director Houghten and of its cooperating institutions. He described the relation of research work of this type to future heating and ventilating problems, showing how the Laboratory is dealing with such fundamentals as the effect of the physical properties of air on the physiological processes of the human body. He prophesied that the next ten years would see a much greater advance than the last ten, and that great progress would be made in the cooling of air for summertime comfort. He pointed out that all fundamental facts will have to be considered, that knowledge of insulation and heat capacity must be broadened, and that our understanding of both radiated and convected heat must be improved.

Professor Rowley showed slides of his research projects at the University of Minnesota which cover all phases of heat transmission through building construction. He concluded his talk by saying that never has there been so great an opportunity for heating and ventilation research as there is at present and by showing why men interested in heating and ventilation should be members of the Society.

At the conclusion Professor Rowley was tendered a rising vote of thanks in appreciation of his talk.

E. C. Evans suggested that the Chapter appropriate $100 to the Pittsburgh Harris Plan for relief of the local unemployed, which suggestion was referred to the Board of Governors for their decision.

Ontario

May 2, 1932. The regular meeting of the Ontario Chapter was held at the Engineers Club, and was attended by 28 members. This was a business meeting for members only.

Following the dinner, Pres. H. S. Moore outlined the activities of the Chapter during the past year. A. J. Dickey who audited the Treasurer's books made a report on the finances of the Chapter for the past year and it was gratifying to the Society to know that the financial condition of the Ontario Chapter at the end of the year for 1931-32 was more substantial than the previous year.

E. Holt Gurney made a report on the membership, stating that there have been two new memberships during the past season, three reinstatements, and seven Ontario Chapter limited memberships.

M. F. Thomas, the Society's representative on the City of Toronto Smoke Abatement Committee, made a report on the activities of that Committee.

Election of officers was held with the following results:

President—J. S. Wood.
Vice-President—W. H. Boddington.
Secretary-Treasurer—H. R. Roth.
Board of Governors—M. W. Shears, J. S. Paterson, W. R. Blackhall and H. S. Moore.

President Moore turned the chair over to the incoming President, J. S. Wood, who spoke briefly on the activities of the Chapter for the coming year.

April 14, 1932. Forty-three members and guests attended the April meeting of the Ontario Chapter held at the Prince George Hotel.

Pres. H. S. Moore called upon A. V. Hutchinson, Secretary of the Society, who spoke on the activities of the National organization and emphasized the fact that President Rowley's greatest problem at present is to increase the membership of the Society.

M. Barry Watson stated that the present building by-laws of the City of Toronto are very old and in many cases are obsolete in regard to present practices in construction. At the present time the City of Toronto has organized a Committee to revise these building by-laws. This committee consists of members of the City Architectural staff and members of organizations such as the Engineering Institute of Canada. Mr. Watson put a motion before the members that the Society be represented on this committee, if physically possible.

The motion appointed a committee to find out who the Chairman of the new building by-laws committee is; to find out who makes appointments to this committee; and to find out if there is a possibility of the Society having a representative on this committee.

The committee to investigate these various points, consists of H. H. Angus, *chairman;* A. J. Dickey and A. S. Leitch.

The motion was seconded by H. J. Church, and carried. President Moore then called upon H. H. Angus to introduce the speaker of the evening, Pres. F. B. Rowley, who addressed the meeting on, Looking Forward in the Science of Heating and Ventilation.

Following his address, President Rowley showed a number of slides illustrating the insulating properties of different types of wall construction. These slides were of utmost interest to all those present.

Mr. Dickey extended a vote of thanks to President Rowley not only for his splendid address but also for visiting the Ontario Chapter.

Philadelphia

April 14, 1932. The monthly meeting of the Philadelphia Chapter was held in the Auditorium of the Engineers Club, with Pres. E. N. Sanbern presiding.

The minutes of the previous meeting were read and approved, followed by the Treasurer's report which was also approved as read.

The following members were elected to serve on the Nominating Committee: E. N. Sanbern, J. D. Cassell, H. P. Gant, W. F. Smith and A. A. Miller.

J. H. Hucker, chairman of the Meetings Committee, then took charge of the meeting. A film on the subject of the Manufacture of Fire Brick and Refractories prepared by the Harbison-Walker Refractory Co., was shown.

Mr. Hucker introduced George Bach, vice-president of the Union Iron Works, who presented a most interesting talk illustrated by slides, on the subject of the Design of Power Boilers and Their Application to Heating Systems.

After a general discussion by several members the meeting was adjourned with a vote of thanks to the speakers.

Southern California

April 11, 1932. The Southern California Chapter monthly meeting held at the California Institute of Technology was attended by 250 members and guests. Contrary to the usual custom this was not a dinner meeting, and therefore there was no business transaction. The meeting was held under the auspices of the Institute, and papers were presented by Dr. A. L. Klein and W. Ager.

Dr. Klein, Assistant Professor of Aeronautics, demonstrated the aeronautics wind tunnel which developes a total dynamic pressure of 20 in. Mr. Ager, Teaching Fellow of Electrical Engineering at the Institute then described the 1,000,000 volt transmission equipment. The wind tunnel demonstration was a revelation to those present, and the electrical show was of unusual interest. Several members, particularly those interested in aeronautics, stayed until midnight while Dr. Klein went into the more technical phases of wind tunnels and their relation to aeronautics. He also explained Dr. Anderson's Cosmic Ray Machine.

The general opinion seemed to be that this meeting was the most interesting that has ever been attended by any of the members of the Society.

Of Interest to Members

N. D. H. A. to Meet in June

The *National District Heating Association* will meet June 14-17 at the William Penn Hotel, Pittsburgh, Pa. The program provides for six business sessions and a number of inspection trips and special entertainment features for the ladies.

Driscoll Visits Kentucky

W. H. Driscoll recently addressed the engineering students at the University of Kentucky in Lexington, Ky., as a guest of Dean F. Paul Anderson, head of the College of Engineering. Mr. Driscoll talked on the subject of sky-scrapers and related some of his experiences in the erection of many well known buildings of the country, such as the Woolworth Building, the Waldorf-Astoria Hotel, and others. During his stay in Lexington, Mr. Driscoll spoke to the Rotary Club of Lexington and at the meeting of the Woman's Club of central Kentucky on the subject of Living in Comfort Indoors.

Air Conditioning Interests Furnace Manufacturers

The spring meeting of the *National Warm Air Heating Association* was held in Columbus, Ohio, May 18-19, at the Deshler-Wallick Hotel, and, in the absence of President I. L. Jones, Vice-President McGrath presided. The first session on Wednesday morning was devoted to papers on business opportunities, credits and selling costs. The afternoon session was in charge of F. G. Sedgwick, Chairman of the Research Committee and presentation of reports on recent developments were given by Professor A. C. Willard of the University of Illinois, Professor A. P. Kratz and S. Konzo.

In the evening a buffet supper and entertainment were enjoyed by all present and H. T. Richardson filled the role of master-of-ceremonies.

On Thursday four papers were given and the reports of the various officers and committees were presented. H. C. Murphy spoke on air pollution; Prof. R. B. Leckie, Purdue, talked on gaseous fuels; Dean F. Paul Anderson of the University of Kentucky spoke on comfort, and B. L. Schwartz, Pittsburgh, talked on dealer activities and opportunities.

Heating and Piping Contractors at Detroit

The *Heating and Piping Contractors National Association* held its 43rd annual convention at the Book-Cadillac Hotel in Detroit, Mich., May 16 to 18, and in the business sessions received reports of its many active committees on standards, welding practice, merchandising, education and legislation. In addition two outside speakers were on the program, Colonel J. B. Walsh, Vice-President of the Guardian Detroit Union Bank, and W. S. Powell of Campbell-Ewald Co.

Greetings from the A. S. H. V. E. were brought by J. F. McIntire, member of the Council, who spoke on the Society's research activities and expressed the appreciation of the committees on research for the cooperation always given by the contractors' organization.

New officers were elected, who were: *President*, R. D. Wil-

liams, New York; *Vice-President,* J. L. De Neille, St. Louis; *Treasurer,* J. H. Zink, Baltimore. New directors are: R. L. Spitzley, Detroit; J. A. Kiesling, Houston, Texas, and Thomas O'Callaghan, Boston.

The important social events were a get-together party on Monday evening, the annual dinner dance on Tuesday evening, and an afternoon of golf and visits to various industrial plants on Wednesday.

Engineering Students Organize at N.Y.U.

As a result of introducing a heating and ventilating course in the Engineering School at New York University, the senior engineering students believed that a Student Branch of the A. S. H. V. E. would be helpful so that a preliminary organization was formed and a petition filed with the Council for a charter. Twenty students attended the first meeting when Prof. R. D. Morrill outlined the aims and activities of the A. S. H. V. E. and the benefits that might be derived by the young engineers. A constitution and by-laws was prepared and adopted subject to approval by the Society. The officers elected to serve for the remainder of the school year were: *President*—William Rozett, Jr., '32; *Vice-president*—Herbert Maiman, '33; *Secretary*—Herbert Austin, Jr., '33; *Treasurer*—John C. Bruckmann, '32; and *Faculty Adviser*—Prof. R. D. Morrill.

N. Y. U. Student Branch of A. S. H. V. E., May 10, 1932
(Left to right, front row) John C. Bruckmann, Treas.; William Rozett, Jr., Pres.; Prof. R. D. Morrill, Faculty Adviser; A. V. Hutchinson, Secy., A. S. H. V. E.; Herbert Austin, Jr., Secy.; and Herbert Maiman, Vice-Pres.

At meetings held during April and May, the speakers were Clarke Redfield, '32—Heating and Ventilating Research; Herbert Austin, Jr., '33—Insulation Tests and Sales; A. V. Hutchinson, secretary of the A. S. H. V. E., The Value of A. S. H. V. E. Membership; and Dr. A. A. Adler, consulting engineer, Some Aspects of the Heating and Ventilating Profession.

For the coming year Herbert Austin, Jr., '33, has been selected as president of the Student Branch and when meetings for the season commence in September, it is expected that the first student organization of the A. S. H. V. E. will make a flying start.

Until January 1932, heating and ventilating as a course in the Engineering School had been unknown to the day student at N. Y. U., but an opportunity was afforded several of the seniors to take work in this branch of engineering and the faculty has considered the subject important enough to warrant its adoption as a required course for senior mechanical engineering students beginning in 1933.

Testing Laboratory Facilities

A description of the Frost Laboratory, Norristown, Pa., appears in the recently issued *Test Log,* which also describes the methods of boiler testing, the equipment for studying automatic fuel burning devices and the facilities available for testing radiators and heating specialties.

G. E. to Make Oil Burner Furnace

The announcement of the organization of an air-conditioning department of the General Electric Co., Schenectady, has been announced by Pres. Gerard Swope, who states that this new unit will market electrical devices for home heating, humidifying and temperature control. J. J. Donovan will be Manager and associated with him will be E. D. Harrington, in charge of application engineering; J. R. Rue, in charge of manufacturing and H. S. Woodruff will be responsible for design engineering. Headquarters will be maintained at the New York Office of General Electric Co., 120 Broadway.

A. O. B. A. Publishes Law Digest

A 344-page brochure by S. A. Raboy, New York lawyer, entitled, A Digest of Law and Cases on Heating Systems and Devices, has recently been announced by the *American Oil Burner Association.*

Frequent requests for help on legal problems, which were impossible to answer because of the research work necessary, prompted the Association to engage a capable lawyer to develop a digest of legal opinion and rulings as they apply to the oil burner industry.

It is believed that Mr. Raboy's study will be a valuable addition to any legal library. While it is not designed to take the place of legal counsel, a study of its contents should assist in reaching a possible solution to many perplexing matters.

Not only can the work prove valuable in avoiding unforeseen litigation, but it will prove to be equally helpful to counsel in establishing a satisfactory defense after litigation has begun.

Acoustical Society Meets in New York

The 7th meeting of the Acoustical Society of America was held in New York, May 2 and 3. Thirty-one papers were presented at the five sessions and covered a wide range of subjects in the field of acoustics. On Monday evening, May 2, a demonstration was given at the Bell Telephone Laboratories by H. A. Frederick showing the development of high quality phonograph records. The problems of microphone placement and orchestral music pick-up were discussed, by J. P. Maxfield. The subject, New Horizons in Music, was presented by Leopold Stokowski, Conductor of the Philadelphia orchestra, who pointed out the tremendous changes in the art of music which new methods of sound control have brought about and gave some hint as to the future development of the musical art in which present day physicists are contributing.

Other subjects of interest were Transmission of Sound Through Doors, by P. E. Sabine; Factors Which Affect the Measurement of Sound Absorption, by Chrisler, Snyder and Miller; Resonance in Rooms, by V. O. Knudsen and Acoustical Measurements, by R. L. Hanson.

The officers of the Association are President, Dr. D. C. Miller, Professor of Physics, Case School of Applied Science, Cleveland; Vice-President, H. A. Frederick, Bell Telephone Laboratories, New York; Treasurer, E. E. Free, New York, and Secretary, Wallace Waterfall, Chicago. Executive Council—F. A. Firestone, Ann Arbor, Mich.; H. D. Arnold, New York City; G. W. Stewart, Iowa City, Iowa; V. O. Knudsen, Los Angeles, Calif.; E. W. Kellogg, Camden, N. J.; F. A. Saunders, Cambridge, Mass.

CANDIDATES FOR MEMBERSHIP

The Constitution of the Society as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the JOURNAL of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Membership Committee as soon as possible.

When the Membership Committee has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 12 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some members by June 15, 1932, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
ABRAHAM, LEONARD, Student, New York University, New York, N. Y.	R. D. Morrill A. C. Coonradt—*ASME*	E. H. Hamilton—*SAE*
AUSTIN, HERBERT F., JR., Student, New York University, New York, N. Y.	R. D. Morrill C. E. Gus—*ASME*	C. P. Bliss—*ASME* W. R. Bryans—*ASME*
BADGETT, W. HOWARD, Research Asst., Texas Engrg. Experiment Station, Agric. & Mech. College of Texas, College Station, Texas.	F. E. Giesecke E. G. Smith	P. D. Close A. V. Hutchinson
BRUCKMANN, JOHN C., Student, New York University, New York, N. Y.	R. D. Morrill E. H. Hamilton—*SAE*	C. E. Gus—*ASME* W. R. Bryans—*ASME*
CHILD, L. WALLACE, Chf. Engr., Air-Way Elec. Appl. Corp., Toledo, Ohio	C. W. Colby E. J. Vermere	C. F. Eveleth E. Szekely
COOPER, JOHN WILLIAM, Dist. Repr., Buffalo Forge Co., St. Louis, Mo. (*Advancement*)	Paul Sodemann G. A. Helwig	F. B. Rowley C. A. Pickett
JANCO, NATHAN, Student, New York University, New York, N. Y.	R. D. Morrill A. C. Coonradt—*ASME*	C. P. Bliss—*ASME* W. R. Bryans—*ASME*
RAFFES, ABRAHAM, Student, New York University, New York, N. Y.	R. D. Morrill C. P. Bliss—*ASME*	C. E. Gus—*ASME*
REDFIELD, CLARKE, Student, New York University, New York, N. Y.	C. P. Bliss—*ASME* A. C. Coonradt—*ASME*	R. D. Morrill W. R. Bryans—*ASME*
ROZETT, WILLIAM, JR., Student, New York University, New York, N. Y.	A. V. Hutchinson R. H. Carpenter	R. D. Morrill A. C. Coonradt—*ASME*
THOMPSON, DONALD, Safe Harbor Water Power Corp., Baltimore, Md.	M. S. Titus M. B. Wright	N. H. Shillman—*ASME* J. B. Cutler—*ASME*
WHITE, JOHN CULBERTSON, State Power Plant Engr., State Bureau of Engrg., Madison, Wis.	G. L. Larson D. W. Nelson	F. G. Weimer W. F. Noll

Candidates Elected

In past issues of the JOURNAL of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Membership Committee and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. II, Sec. VIII, of the By-Laws, the following list of candidates elected:

MEMBERS

BALSAM, CHARLES P., Mgr., Refrig. & House Heating Div., Washington Gas Light Co., Washington, D. C.

HAKES, LEON MARC, The R. T. Coe Cos., Rochester, N. Y. (*Advancement*)

SPERLING, H. EDWARD, The Fred Christen & Sons Co., Toledo, Ohio.

STEELE, JOHN BEAUMONT, Chief Engr., Winnipeg School Board, Winnipeg, Manitoba, Canada.

THORNBURG, HAROLD A., Sales Engr., Carrier Engrg. Corp., Cincinnati, Ohio (*Advancement*)

ASSOCIATES

BERRY, FEROL WAYNE, Hall-Neal Furnace Co., Indianapolis, Ind.

BOWERS, ROSS C., Sales Mgr., Minneapolis-Honeywell Regulator Co., Milwaukee, Wis.

LYONS, CORNELIUS J., Nash Engineering Co., South Norwalk, Conn.

OAKEY, WILLIAM E., Babcock Manufacturing Co., Leonardsville, N. Y.

POLLARD, ALFRED L., Genl. Supt., Steam Heat Dept., Puget Sound Power & Light Co., Seattle, Wash.

JUNIOR

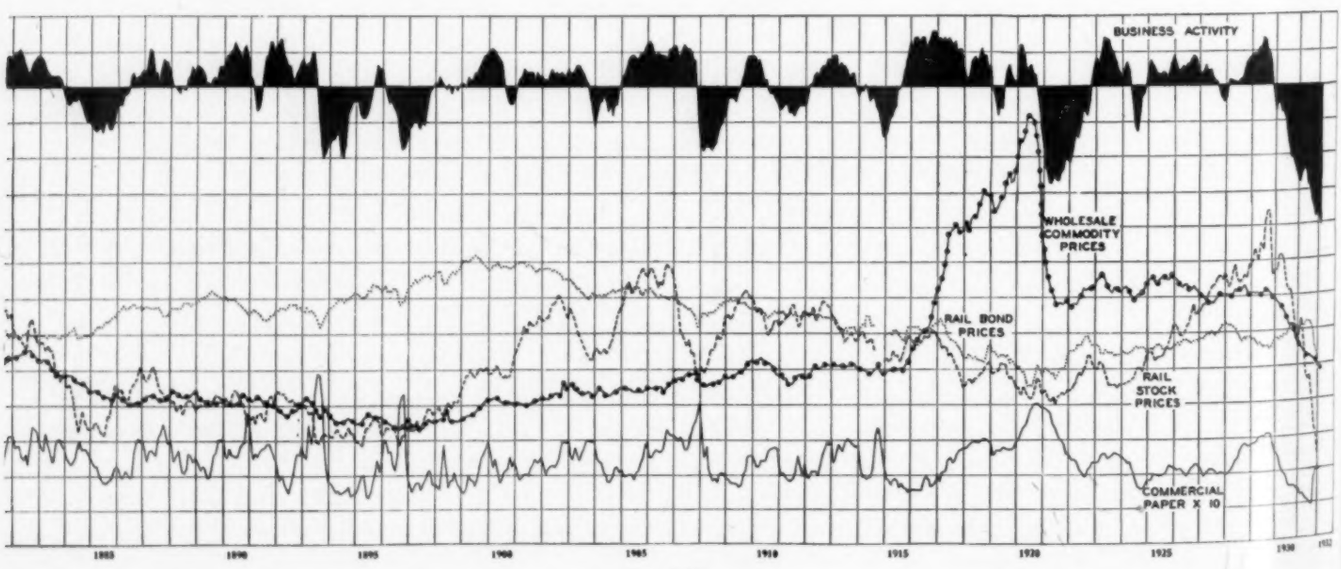
KONZO, SEICHI, Special Research Associate, University of Illinois, Urbana, Ill.

PREPARING *FOR* TOMORROW

Below is a chart showing the ups and downs of business over a period of years; it is a portion of a chart which goes back to 1790 and was prepared by the Cleveland Trust Company. In spite of the ominous black spot at the right—which shows no upward trend—this is presented as an optimistic, rather than a pessimistic, graph.

It is an old saying that whatever goes up must come down, and looking back over the years it is observed that whenever business has gone down, it later has come up.

It appears that no one is in sympathy with the patent official who, one hundred years ago, resigned his position because he thought there was nothing else to invent. We prefer the point of view of Professor Millikan, who stated that the next ten years will reveal far greater advancement than all previous history. That part of this activity will take place in the heating, piping and air conditioning industry is revealed by the report of a concern of patent attorneys of national coverage. This concern states that while there has been a sharp decline in the total number of patents applied for, there has been an increase in the number of applications for patents for heating, cooling and air-conditioning devices. In recent weeks, about twelve heating, cooling and air-conditioning patents have been issued each week. While every one of these devices probably will not come into general use they serve to crystallize the nation-wide interest in air conditioning and cooling; the lesson for the designing, operating and maintenance engineer would seem to be to study these new developments which may enable him to render a better service and so prepare for the time when the black spot at the end of the chart will show an upward trend.



On the Job

. . . . a department devoted to short, practical articles on the installation, operation and maintenance of air conditioning, heating and piping equipment . . . . . .

Installing Globe and Angle Valves

By W. H. Wilson

OPINIONS differ as to the correct method of installing globe and angle valves, as regards the direction of flow with reference to the disc of the valve. General custom and practice is to install the valve so that the flow through the line will be stopped by the side of the valve disc opposite to the side bearing on the end of the stem (the under side of the disc).

When a section of the pipe line shut off is drained (the valve being installed in this position) the pressure is relieved from the interior of the valve body containing the stem, and the valve stem can be repacked. This is shown at *A*, Fig. 1. The end of the valve at *A* is termed the "pressure side." Valves of the globe and angle pattern are, in the majority of cases, installed in this manner.

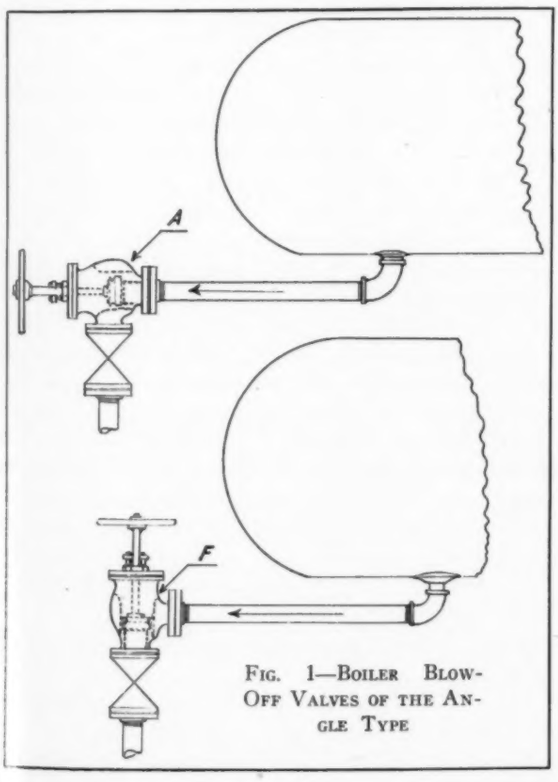


FIG. 1—BOILER BLOW-OFF VALVES OF THE ANGLE TYPE

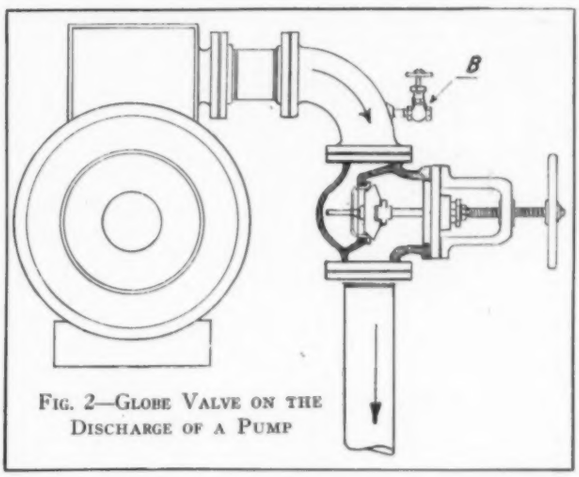


FIG. 2—GLOBE VALVE ON THE DISCHARGE OF A PUMP

Maintenance men have found that the installation often determines the method of installing such valves. Fig. 2 shows a large size globe valve on the discharge of a boiler feedwater pump. The flow of water from the pump comes through the valve under the disc. When the pump is shut down for repairs the feed line pressure helps to keep the disc firmly seated. If the valve were installed so that flow through it were reversed and the valve disc should become detached from the valve stem, it would automatically close the valve, similar in action to a check valve. In the case of a boiler feed pump in operation, this would in all probability be of serious consequence. A drain valve *B* should be installed to relieve the pressure when the water end of the pump is to be opened for repairs. Should the valve leak through from the feed line, the hot water will pass out through the drain valve and not interfere with the repair work.

Fig. 3 shows an angle valve as a stop valve for the feedwater line supplying a boiler. This valve is used when it is necessary to inspect and repair the check valve, the boiler being under pressure. Installed as shown at *C*, the flow has a tendency to detach the valve disc from the stem, which would close off the valve and prevent water from entering the boiler. It would seem better to install the valve as shown at *D;* the flow of water to the boiler will then not be stopped by a loose valve disc. Check valves and stop valves installed

in this manner may be provided with a small drain tapping and valve at *E* in order that the pressure can be relieved when maintenance work is necessary. This will prevent injury to a workman when the boiler is under pressure.

Fig. 1 shows boiler blow-off valves of the angle type. Installed as at *F* there is a tendency for the disc to become detached from the stem and close the port. The interior of the valve body also becomes a settling chamber for impurities in the boiler feedwater. A better installation would seem to be that shown at *A*. In connection with this, it should be stated that some types of boiler blow-off valves, on account of their interior seating parts, should be installed with the side opening of the valve as the inlet from the boiler.

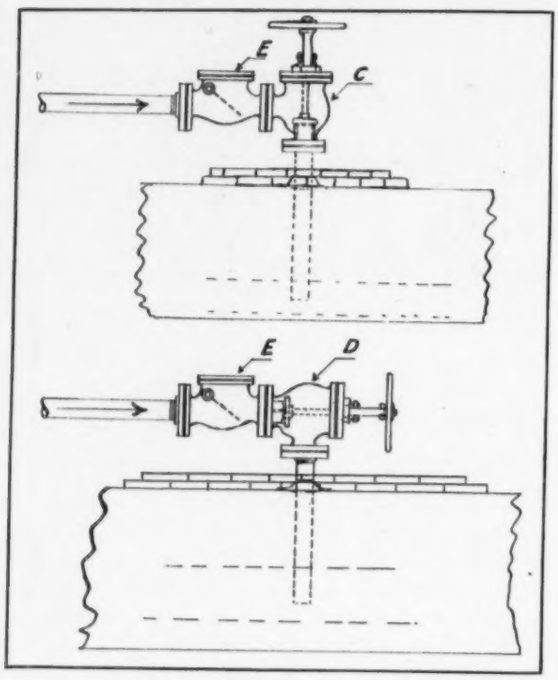


FIG. 3—ANGLE VALVE AS A STOP VALVE ON A FEEDWATER LINE

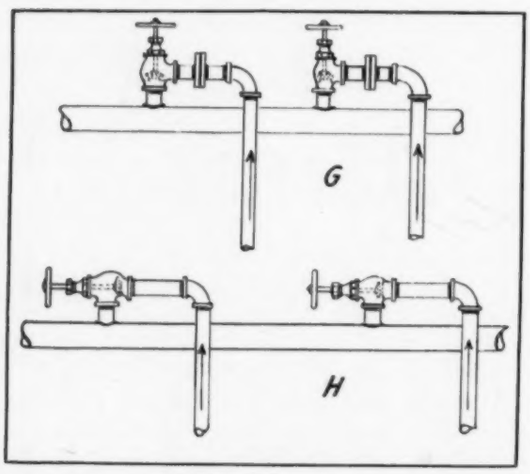


FIG. 4—ARRANGEMENT OF SHUT-OFF VALVES IN A STEAM EXHAUST LINE

Fig. 4 shows an arrangement of shut-off valves for the steam exhaust line from boiler feedwater pumps; the original installation is shown at *G*. This was changed to that shown at *H* because of the possibility of a valve disc becoming detached, closing off the exhaust and stopping the operation of the pump.

Modernized Department Store Heating System Cuts Cost

THE department store of Hutzler Brothers, Baltimore, Md., occupies five separate brick buildings, together with a garage and a service building; the five main buildings are connected by overhead bridges. Nearly 5,000,000 cu. ft. of space is heated by a recently-installed controlled gravity steam heating system. The building layout is illustrated in the branch main and control diagram in Fig. 5.

The South building is a five-story and basement structure fully exposed to the north and east.

The Clay street building has six stories and basement and is fully exposed, west and south.

The Saratoga street building is of ten stories with basement and pent house, fully exposed north and west below the fifth floor and on all four sides between the sixth and tenth floors.

The Howard street building, with four stories and basement, is about one-third exposed to the north and fully exposed on the east side.

The last of the five buildings, the North Annex, is a five-story structure fully exposed east and west and one-third exposed on the south.

The basement space occupied by the boiler plant in the Clay street building was badly needed for sales purposes. In addition, both boilers and auxiliary equipment were rapidly approaching the end of their useful lives. A modernization program was indicated and it was finally decided to dismantle the boiler plant entirely and to purchase steam from the street mains. A 100-lb. line was brought in for miscellaneous process uses and a low-pressure connection was made to supply steam for heating purposes at approximately 10-lb.

The direct radiation in the five main buildings was placed under control of a system in which the steam flow to all radiators is adjusted automatically for changes in outdoor temperature, in amounts of radiation in service, and for fluctuation in supply pressure; at the same time it was decided to convert the system to open return line operation. About 500 sq. ft. of additional radiation was installed, bringing the total up to 35,472 sq. ft.

Low-pressure lines were taken off ahead of the main steam control valve to supply steam to existing direct radiation in the garage building, service building, and basement-store ventilating system. The store's hot water service is obtained by passing the returning condensate through the economizer and if necessary building up to required temperature by means of high-pressure steam.

Operating procedure during the heating season is to turn steam on at 5:30 a.m. on business days with the control at 200 per cent. The engineer then makes his daily rounds of the building, then sets the control back to 100 per cent when the building reaches approximately

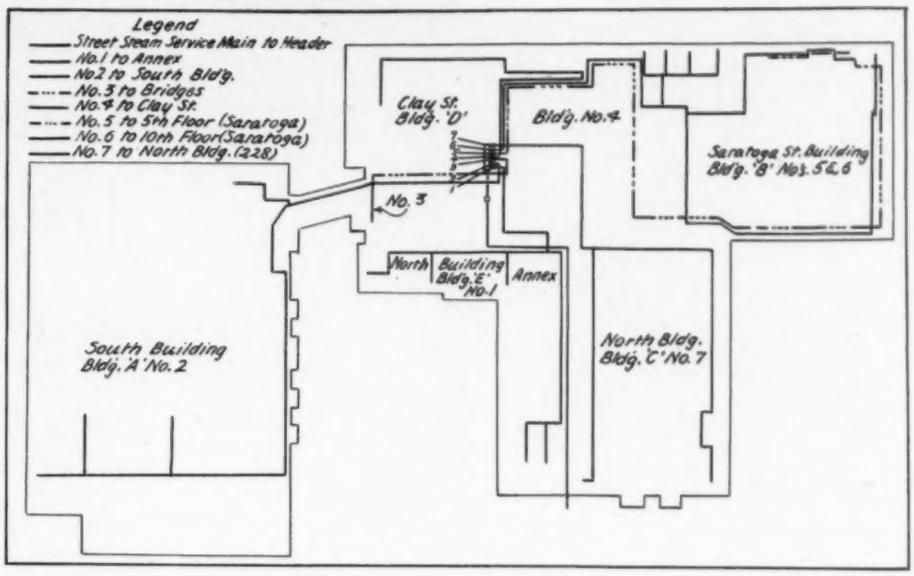

Legend
Street Steam Service Main to Header
No.1 to Annex
No.2 to South Bldg.
No.3 to Bridges
No.4 to Clay St.
No.5 to 5th Floor (Saratoga)
No.6 to 10th Floor (Saratoga)
No.7 to North Bldg. (228)
Clay St. Bldg. 'D'
Bldg. No.4
Saratoga St. Building Bldg. 'B' Nos. 5 & 6
No. 3
North Building Bldg. 'E' No.1
Annex
South Building Bldg. 'A' No.2
North Bldg. Bldg. 'C' No.7

FIG. 5—BRANCH MAIN AND CONTROL DIAGRAM FOR A MODERNIZED DEPARTMENT STORE HEATING SYSTEM. RADIATION IS DIVIDED INTO SEVEN ZONES

72 F, at about 8:30 a.m. The 100 per cent-control setting is retained ordinarily until 5 p.m. At that time it is shut down to 50 per cent, where it remains until complete shut-off of steam at 6:30 p.m.

Radiation is divided into 7 zones, each zone being governed by a manually-operated branch valve or adjustable orifice. These valves are shut, opened to 100 per cent or normal (giving a steam flow proportionate to the normal requirements of the section served), or are set at any percentage up to 50 per cent above normal. Fig. 5 shows the arrangement of zones with branch valves. These branch valves were set at 50 per cent when the use of large lights in the sales areas contributed a substantial quantity of heat.

1.	Type of System	Gravity Steam with Control	
2.	Heating Season	1929-30	
	Period covered by records:		
	From	Nov. 11	
	To	April 30	
	Days	171	
3.	Steam Consumed:		
	Pounds	6,878,900	
4.	C. I. Radiation and Piping: (EDR @ 240 Btu/sq. ft.)	35,472	
5.	Average Inside Temperature Maintained	72 F.	
6.	Season Heating Load, Degree Days:		
	Totals	4,467	
	(a) For temperature below 65 F	3,067	
	(b) For difference between 72 F and 65 F	1,001	
	(c) For average wind velocities of 9.64 and 9.81 m.p.h.	399	
7.	Operating Rate:		
	(a) Hours per week		
	(b) Rate-hours per week	76.0	
	(c) Per cent of maximum rate-hours	45.2 per cent	
8.	Rates of Steam Consumption (Radiation and Piping, EDR):		
	(a) Per sq. ft. per season	193.9 lb.	
	(b) Per sq. ft. per degree day	0.0434 lb.	

The Sight Flow in Piping Systems

A SIGHT flow is essential in many pipe lines, such as those for air-compressor cooling jackets, water-cooled bearings for forced- or induced-draft fans, hydraulic turbines, oil coolers for centrifugal pump thrust bearings, oil and water circulating lines of diesel and other engines, transformers, and for numerous chemical and industrial processes. A method of keeping watch on the flow of cooling water (or other liquid) is by means of a funnel which receives the flow from a vertical pipe nozzle. These funnels are usually made from various odds and ends of fittings, and some of them are atrociously ugly.

Several years ago the writer designed a funnel similar to Fig. 6 for a large refinery power plant. About 175 were required, and more were afterward ordered for use about the refinery. As this refinery had first-class

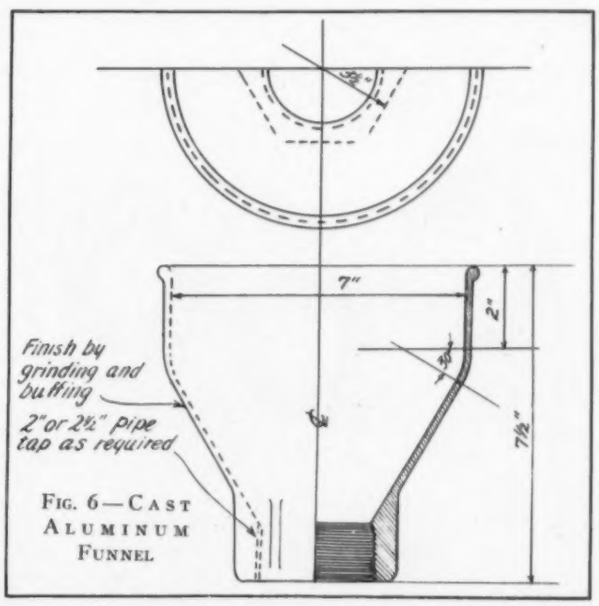


FIG. 6—CAST ALUMINUM FUNNEL

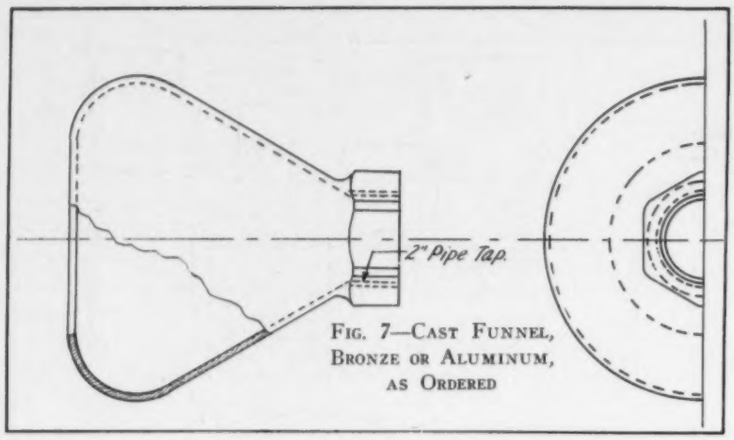


FIG. 7—CAST FUNNEL, BRONZE OR ALUMINUM, AS ORDERED

foundry and machine shop facilities, these aluminum funnels cost very little; moreover, they added somewhat to the appearance of a fine piping installation.

Fig. 7 illustrates another funnel design, more ornamental than Fig. 6 and more costly because of the necessity of coring the casting.—F. E. W.

Use of the Proper Piping Material Important

SELECTION of the material that is proper for the pressure and the nature of the contents transmitted through pipe lines is one of the essential points of good pipe installation; this is important when selecting the seating parts of valves.

Fig. 8 shows three valve discs that have been removed from pipe lines. *A* was removed from a fuel-oil line. This was a standard-type disc used for the ordinary pressures. The picture shows the disc after two weeks service on fuel oil. *B* is a disc of oil proof composition and was removed from the same line as was *A* after a year's service. It shows no appreciable amount of wear on its seating faces.

C shows a disc of the same type as *A* which was removed from a water line carrying 75 lb. pressure, at atmospheric temperatures. It is in good condition after being in use for some time.

The illustration indicates that valve discs of the proper material for the service should be used.—*W. H. Wilson.*

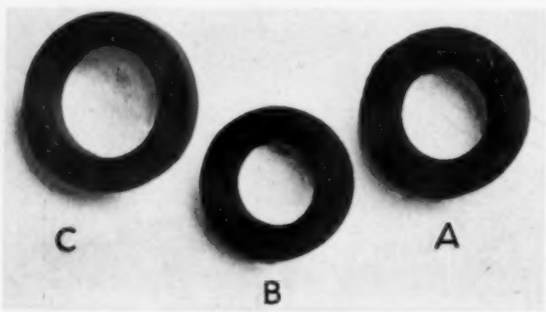
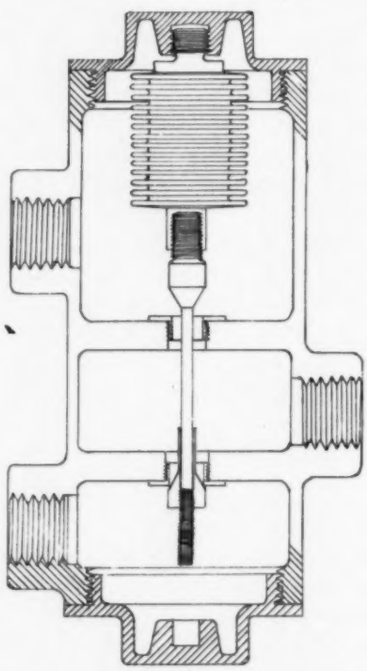


FIG. 8—*A* IS A STANDARD-TYPE DISC AFTER USE ON A FUEL LINE, AND *B* IS A DISC OF OIL-PROOF COMPOSITION AFTER A MUCH LONGER PERIOD OF SERVICE. *C*, A DISC OF THE SAME TYPE AS *A* AFTER USE ON A WATER LINE

INTERESTING Equipment . . . Developments

Control for Steam-Heating Systems

• A new method of controlling steam-heating systems depends upon venting the ends of the steam lines and the return lines separately and holding the vent from the return lines sealed until all of the steam lines have been vented. This is to prevent any tendency for the first radiators on the line to receive more steam than the last radiators when the system is operated intermittently or at reduced capacity. No air can escape from the first radiators while the steam mains are filling, and steam is made available to all radiators at the same time.



The device used to accomplish this purpose is illustrated here. A thermostatic element in its top operates valves which close the vent from the return lines and open the vent from steam lines as long as it is cold. When steam from the steam mains strikes the element, it operates to close the vent from the steam lines, preventing the escape of steam, and opens the vent from the return lines, permitting the escape of air. In the illustration the steam connection is at the left top, the return connection at the left bottom, and the vent connection at the right.

In large systems, ends of all steam mains are dripped and vented through float and thermostatic traps into a separate return, which has no connection to the returns from the radiators. This separate return is run to the vacuum pump direct and free from any water pockets or traps.

A water seal of 6 or 12 in. is then inserted in the regular return just before it enters the vacuum pump.

With this arrangement the vacuum pump will draw air from the preferred return line which has no water seal in it as long as it can do so in preference to drawing air through the water seal in the regular return. As a result, steam will be drawn to the ends of all the steam lines before the water seal will be broken in the regular return. When all of the thermostatic traps at the ends of the steam lines have been closed by the presence of steam, the vacuum pump will no longer be able to draw air from the preferred return, which will cause an increase in vacuum at the pump sufficient to blow the water seal, and air will then be withdrawn from the regular return. Steam will then be available at the branches to all the radiators. This system of control has been introduced by the F. I. Raymond Co., 629 W. Washington boulevard, Chicago.

Valve for 125-Lb. Steam, 175-Lb. Water

• A new standard bronze solid-wedge stationary-stem gate-valve for 125-lb. steam pressure and 175-lb. water pressure has lately been placed on the market. A feature is the extra large bonnet hex placed close to the hub face joint where it screws into the body; this construction is designed to make the valve particularly rigid and to assist in the removal of the bonnet and stem assembly when installation clearances are close.

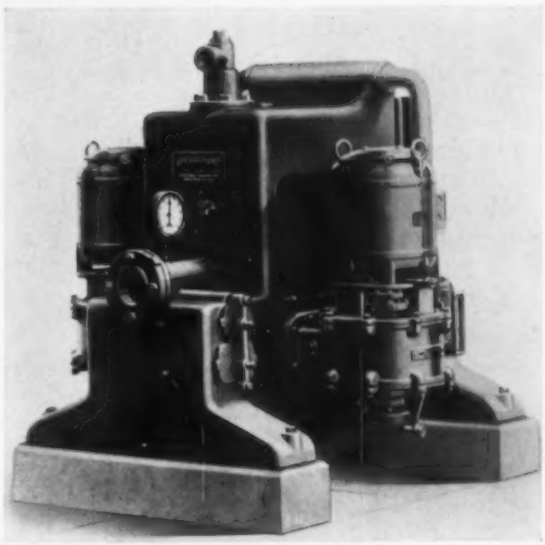
The depth to which the stem engages with the disc provides a large number of contact threads to eliminate possibility of stripping. The pipe and hexes are made heavy. The stuffing box is provided with a gland on all sizes and the packing rings are of molded square section and made of a composition which has a high graphite content. The maker is The Kennedy Valve Mfg. Co., Elmira, N. Y.

New Low-Return Pump

• A new type of vacuum heating pump recently made available has several principal points of difference from previous models. The new type is a low-return pump; condensate from the system enters the low-return inlet on a level with the water storage chamber eliminating need for an accumulator tank and separate float chamber except in extreme cases where the return line comes in at a particularly low level. The motor (which is a slow-speed motor—1800 r.p.m.—on all units used with pressures under 50 lb.) and pump are mounted on a single shaft in a vertical assembly attached to the side of the receiver tank, the motor being well above pump-room floor level to prevent damage to the motor from water.

By substituting a bellows lever arrangement at the float switch connection, packing at the float arm stuffing box has been eliminated.

This compact pump unit is made by the Ames Pump Company, Inc., 30 Church St., New York City, a division of the American Locomotive Company.

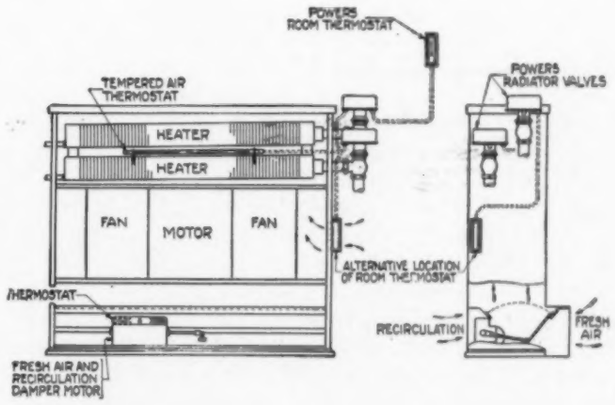


Control for Unit Ventilators

• A new method of applying automatic temperature control to unit heaters and ventilators has been announced. With this method a tempered air thermostat is located in the path of the air as it leaves the preheating section. Set usually for 65-F operation, the arrangement prevents delivery of air to the room at a temperature so low as to cause objectional drafts, or so high as to cause overheating; the tempered air thermostat may be pneumatic, electric or self-contained.

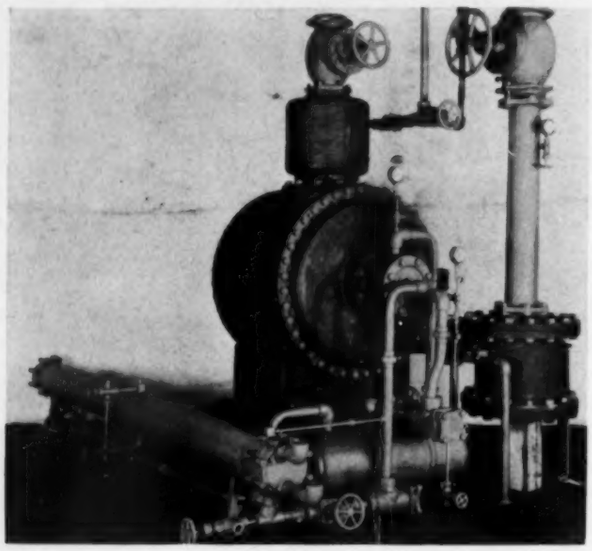
The upper or heating section of the unit is controlled by another thermostat (actuated by room temperature) which may be located at any desired point in the room, or within the unit casing where it is actuated by recirculated air of room temperature.

Fresh air and recirculating dampers are controlled by a thermostat located in the recirculated air intake and thereby controlled by room temperature. This method of control has been patented recently by The Powers Regulator Company, 2720 Greenview Ave., Chicago.



Rotary Compressors for Air Conditioning

• Extensive applications to air-conditioning work are expected by the maker of a new line of rotary compressors which have been developed. The compressors operate through a range of from 14 in. vacuum on the suction side and 40 lb. pressure on the discharge side. A feature of these units is that points of contact on the rotor and in the cylinder casing do not register at the same places at each revolution, but the points of register shift a trifle at each revolution in order to prevent uneven wear.



The units are said to be quiet in operation and economical insofar as foundation and space requirements are concerned. The unit illustrated here is a 500 cu. ft. compressor operated at 600 r.p.m. An oil cooler and oil reservoir are located outside the machine, and an oil pump is fastened to the end of the shaft of the unit. The long shell-and-tube cooler beside the unit is cooled with water. At the right is shown the suction scale trap and the suction line coming to the compressor.

The Vilter Manufacturing Company, Milwaukee, Wis., is the manufacturer.

New Line of Water Meters

• A new model of water meter designed to measure accurately extremely low flows as well as intermediate and high flows is announced. It is built in sizes from 5/8 to 2 in., with normal flow limits 1 to 160 g.p.m. Of the positive displacement disc type, all register gears are fitted with rubber-bushed bearings.

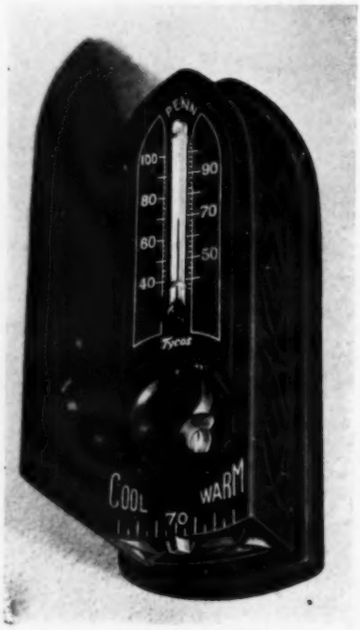
The disc or measuring chamber is in two sections, held together by a snap joint without screws, permitting the case to separate without distortion in the event of freezing. Additional protection is secured by the use of a cast iron frost bottom on the three smaller meters; this bottom breaks when water in the meter freezes, relieving the strain on the interior parts and preventing damage to the meter.

The stuffing box is cast on the main case to eliminate a source of possible leakage as no gaskets or lock nuts are necessary. These meters are an addition to the line of the Worthington Pump and Machinery Corporation, Harrison, N. J.

A Low Voltage Thermostat

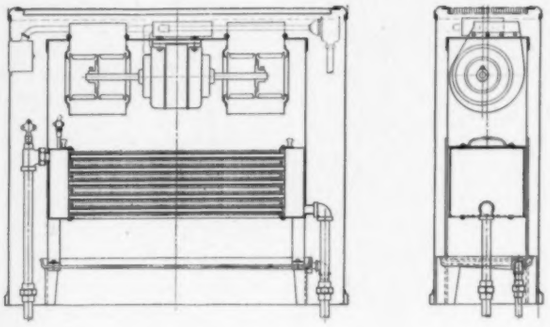
• A new thermostat of artistic design has recently been placed on the market. The base and cover are made of molded bakelite, finished to harmonize with the room in which it is installed. An important feature is that it will operate, without change, on either line or low voltage, two or three-wire control systems. The instrument is 4¾ in. in height and is of a magnetic contact type.

This room control is made by the Penn Electric Switch Co., Des Moines, Iowa.



Cooling and Heating Units

• A new unit system for cooling and heating offices, stores, restaurants, shops and similar areas has just been announced. The units are built in four sizes and types to fit varying needs. Each unit is complete in itself and consists of a dual-purpose coil of special design and construction through which hot water is circulated in winter and cold water in summer, a



motor-driven multiblade fan, a three-speed switch to control volume of heated or cooled air circulated, and a furniture-finished steel casing with a grille top which covers the entire unit.

Installation of the unit may be made in one or a number of offices in a single building, according to the American Blower Corporation, 6000 Russell St., Detroit, Mich., the manufacturer.

Conventions and Expositions

National Electric Light Association: Annual convention, June 6-10; Atlantic City Auditorium, Atlantic City, N. J. Secretary, A. J. Marshall, 420 Lexington ave., New York City.

National Association of Building Owners and Managers: Annual convention and exposition, June 6-10; Drake Hotel, Chicago, Ill.

American Society of Refrigerating Engineers: Spring meeting, June 9-11; Massachusetts Institute of Technology, Cambridge, Mass. Secretary, David L. Fiske, 37 W. 39th st., New York City.

Smoke Prevention Association: Meeting, June 7-10; Royal York Hotel, Toronto, Ontario, Canada. Secretary, F. A. Chambers, City Hall Square Bldg., Chicago, Ill.

National District Heating Association: Annual convention, June 14-17; William Penn Hotel, Pittsburgh, Pa. Secretary, D. L. Gaskill, Greenville, Ohio.

American Society for Testing Materials: Annual meeting, June 20-24, Atlantic City, N. J. Secretary, C. L. Warwick, 1315 Spruce st., Philadelphia, Pa.

American Society of Heating and Ventilating Engineers: Semi-annual meeting, June 27-29; Milwaukee, Wis. Secretary, A. V. Hutchinson, 51 Madison ave., New York City.

American Society of Mechanical Engineers: Spring meeting, June 27-July 1; Bigwin Inn, Lake-of-Bays, Ontario, Canada. Secretary, Calvin W. Rice, 33 W. 39th st., New York City.

American Gas Association: Annual convention, October 10-14; Atlantic City, N. J.

Recent Trade Literature

Air Conditioning: Economy Equipment Company, Inc., Chicago, Ill.; eight-page bulletin discussing air conditioning for candy manufacture. Sections are devoted to chocolate, hard candy, marshmallow, starch drying, caramel, fudge and nougat, pan work, chewing gum, sugar wafers, etc. A chocolate cooling conveyor is described and a conditioner is illustrated.

Air Conditioning Equipment: The Fox Furnace Company, Elyria, Ohio; eight-page bulletin giving technical and general information on gas-fired air-conditioning units for heating, humidifying, filtering and circulating air.

Boilers: Foster Wheeler Corporation, 165 Broadway, New York City; 48-page fully-illustrated catalog describing several types of boilers and showing their applications to steam-generating units. Included are sectional header boilers, both cross-drum and longitudinal; bent-tube boilers, including three-, four- and six-drum types, and boilers of smaller size including three-drum, bent-tube, low-head type and horizontal fire-tube types. Marine boilers of water-tube and Scotch types are also described, as are extended-surface type boilers for recovery of heat from internal-combustion engine exhaust and industrial processes.

Boiler Feeders: McDonnell & Miller, Wrigley Bldg., Chicago, Ill.; loose-leaf data book giving complete installation details, capacity charts, dimension details, wiring diagrams and service recommendations for boiler feeders. An index lists sixty detail drawings showing installation details to as many types or makes of boilers.

Boiler Plants: Combustion Engineering Corporation, 200 Madison Avenue, New York City; reprint of article on modernizing old boiler plants, presenting details of several actual cases which resulted in economies; in each of the cases described stokers were utilized. Also reprints of articles on tangential firing of gaseous and liquid fuels, corner firing of blast furnace gas and combination burning of blast furnace gas and pulverized fuel.

Centrifugal Compressors: General Electric Company, Schenectady, N. Y.; four-page data sheet on single-stage centrifugal compressors (5 to 30 hp.) giving construction details, applications, operating characteristics, etc. Impeller is of cast-aluminum, one piece.

Centrifugal Compressors: B. F. Sturtevant Company, Hyde Park, Boston, Mass.; eight-page bulletin on centrifugal compressors for industrial furnace, conveying and pneumatic tube work. Performance curves and capacity tables are presented, and a description of construction and characteristics is given.

Coolers: Ilg Electric Ventilating Co., 2850 N. Craw-

ford ave., Chicago, Ill.; four-page bulletin describing a portable ice-cooled room cooler.

Circuit Breakers: Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.; eight-page bulletin describing in detail construction and application of de-ionizing 50 to 225-ampere circuit breakers (250 and 600 volts a.c.; 125 and 250 volts d.c.; 1, 2, 3, and 4-pole). A feature is the small amount of space required. A second eight-page pamphlet stresses uses on switchboards, panelboards and for industrial and commercial installations.

Deaerating Heaters: Cochrane Corporation, 17th st. and Allegheny ave., Philadelphia, Pa.; 16-page booklet discussing corrosion of iron and steel by hot water, removal of oxygen, and describing direct-contact deaerating heaters, evaporator deaerators, metering heaters, etc. Red water, deaeration of condensate returns, chemical conditioning of water in central heating plants, storage of hot water, automatic heat storage, etc., are discussed.

Heater and Cooler Tubes: Schutte & Koerting Company, Philadelphia, Pa.; eight-page bulletin on spiral-finned tubes for air heating and cooling equipment; applications and technical information are given; the spiral fins provide a heat transfer surface from 7 to 16 times the contact surface of plain tubes of equal size and length.

Heating and Ventilating Units: John J. Nesbitt, Inc., 11 Park pl., New York City; 32-page catalog describing heating and ventilating units for schools, and giving complete information on types of units, specifications, capacity, detail drawings, control, installation, etc.

Immersion Heating Units: H. O. Swoboda, Inc., 3530 Forbes st., Philadelphia, Pa.; eight-page pamphlet giving engineering and price information on bare electric immersion heating units suitable for heating materials which are electrical insulators.

Instantaneous-Unloaders: Electric Machinery Mfg. Co., 1331 Tyler st., N.E., Minneapolis, Minn.; four-page bulletin describing use and application of instantaneous-unloaders for synchronous motor-driven compressors in ice and refrigeration plants for automatic start and stop and to eliminate shut-downs from voltage dips.

Insulation: Johns-Manville, 292 Madison ave., New York City; 66-page booklet on insulation materials for temperatures from 400 F below zero to high industrial temperatures; a helpful table and chart shows recommended insulation for a wide variety of purposes.

Lubrication: Acheson Oildag Company, Port Huron, Mich.; four-page technical bulletin on graphited oils and their applications, such as lubrication of reduction gears, diesel engines, machines during "running-in period" and other types of equipment which must function under high temperatures or pressures.

Magnetic Switches: General Electric Company, Schenectady, N. Y.; eight-page bulletin on standard general-purpose magnetic switches; each size is described in detail. One section is devoted to modifications for various special services and another describes control accessories.

Meters for Pipe Lines: Schutte & Koerting Company, Philadelphia, Pa.; four-page bulletin describing a meter which indicates at any time gas or liquid flow in a pipe line; it consists of a transparent tube set into a metal frame containing a free top-shaped float and a scale.

Motors: General Electric Company, Schenectady, N. Y.; four-page bulletin on direct-current motors, constant speed, ball- or sleeve-bearing, ½ to 3 hp., 115-230-550 volts, shunt- or compound-wound. Modifications to meet special requirements are discussed, as are features of construction.

Oil Burners: Schutte & Koerting Company, Philadelphia, Pa.; eight-page bulletin giving complete data and descriptions of six types of steam-and-air-jet fuel oil burners and a gas burner for use with natural, illuminating, furnace blast or sewage gases.

Oil-burning Equipment: Motor Wheel Corporation (Heater Division), Lansing, Mich.; 12-page catalog in which is described an oil burner designed so as to give a gyrating flame to provide a highly combustible mixture of oil and air. Dimensions, specifications and other data are included. A six-page folder describes the application of the burner to water-heaters for commercial purposes.

Pumps: Worthington Pump and Machinery Corporation, 2 Park ave., New York City; eight-page bulletin describing and giving rating tables, dimensions and tables of pump combinations with motor characteristics for centrifugal pumps. The pump is bolted to the extended motor frame with the impeller mounted on the end of the continuous motor shaft; uses mentioned include with air-conditioning apparatus, brine and ice-water circulation, etc. Also a folder describing sump and irrigation pumps for heads ranging from 0 to 65 ft. and capacities from 45 to 20,000 g.p.m.

Pyrometers: The Foxboro Company (Wilson-Maeulen Pyrometer Division), Foxboro, Mass.; 16-page bulletin describing and illustrating in detail automatic temperature-control pyrometers for regulating industrial applications of oil, gas and electric heat. Construction, operation and use are described fully.

Traps: Hoffman Specialty Co., Inc., Waterbury, Conn.; eight-page catalog of float and thermostatic traps and high pressure traps; descriptions, capacities, specifications and piping diagrams are included.

Vacuum Cleaning: B. F. Sturtevant Co., Hyde Park, Boston, Mass.; eight-page catalog of tools and attachments for stationary and portable vacuum cleaners.

Water Level Indicators: Schutte & Koerting Company, Philadelphia, Pa.; eight-page bulletin describing an electrically-operated water level indicator for boilers, tanks, and other vessels. The illuminated indicator, which may be installed in multiple, is connected to the boiler by an electric cable.

Welding Rods: The Bastian-Blessing Company, 240 E. Ontario st., Chicago, Ill.; 20-page pocket-size catalog of welding rods and welding and cutting equipment. The various types of rods and their uses are described in detail, and miscellaneous tables of aid to welders are included.

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THE NEW G-E ARC WELDER

Combines and excels all the best features of all the good welders now on the market . . . plus new features all its own.

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11. A definite purpose for every ounce of material

The operator, who is kept busy on repair work in a Mid-Western cement plant, was enthusiastic.

"It sure is a real set. Easy to handle; easy to haul around; holds a steady arc; puts the metal on just the way you want it. She's 100 per cent O.K."

If you are skeptical of testimonials and claims, we hope you will ask your welding distributor or nearest G-E office for a demonstration. Compare the new G-E arc welder with any other welder on the market. While you are investigating this set, ask also about the complete G-E line of welding electrodes and accessories.

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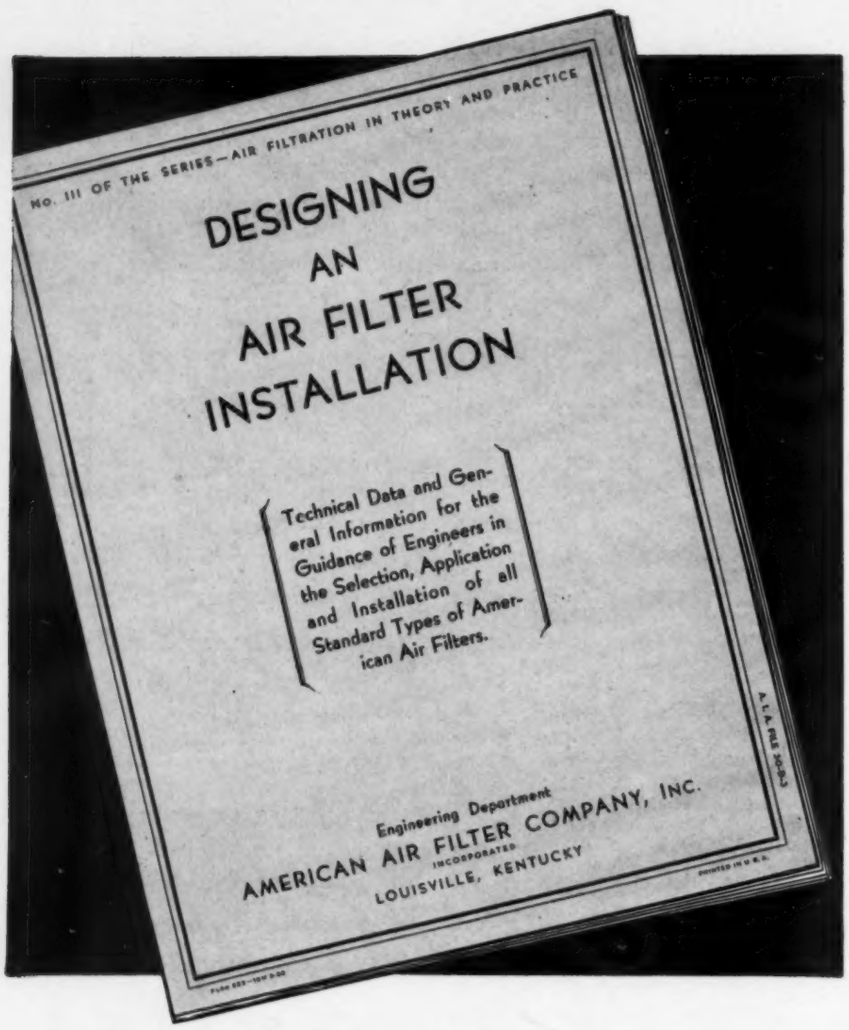
GENERAL ELECTRIC

A HANDBOOK *for* ENGINEERS

Containing Complete Up-to-Date Data for the Design of Air Filter Installation


NO. III OF THE SERIES—AIR FILTRATION IN THEORY AND PRACTICE
DESIGNING AN AIR FILTER INSTALLATION
Technical Data and General Information for the Guidance of Engineers in the Selection, Application and Installation of all Standard Types of American Air Filters.
Engineering Department
AMERICAN AIR FILTER COMPANY, INC.
INCORPORATED
LOUISVILLE, KENTUCKY

"Designing an Air Filter Installation" is made in size and form suitable for filing and is FREE to you upon request. We believe you will find it worth writing for and keeping for constant reference.

Air Filters are usually installed as part of a complete heating, ventilating or air conditioning system.

Such systems include fans, heaters, humidity control and other equipment needed to create and maintain a desired condition of the air.

The performance of the air filter —regardless of its own in-built quality—is necessarily dependent to a considerable extent on its relation to the other equipment of which it is a unit.

The purpose of this handbook is to give the engineer who designs systems requiring air filters the knowledge and experience that has been gained by our engineering department from thousands of such installations.

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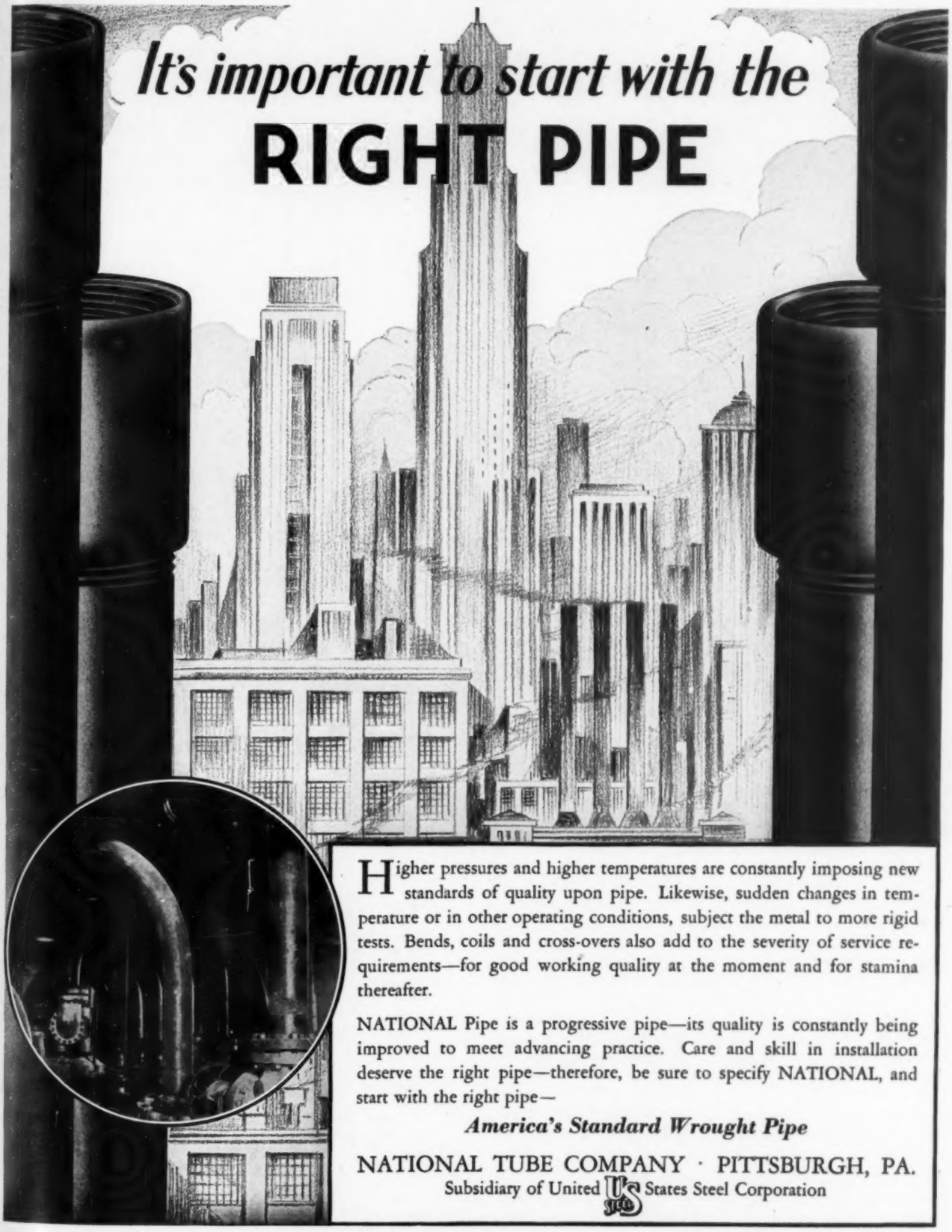

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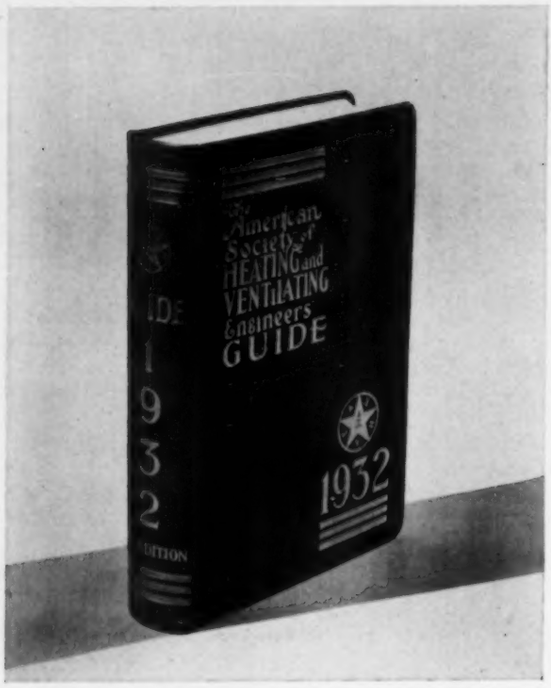

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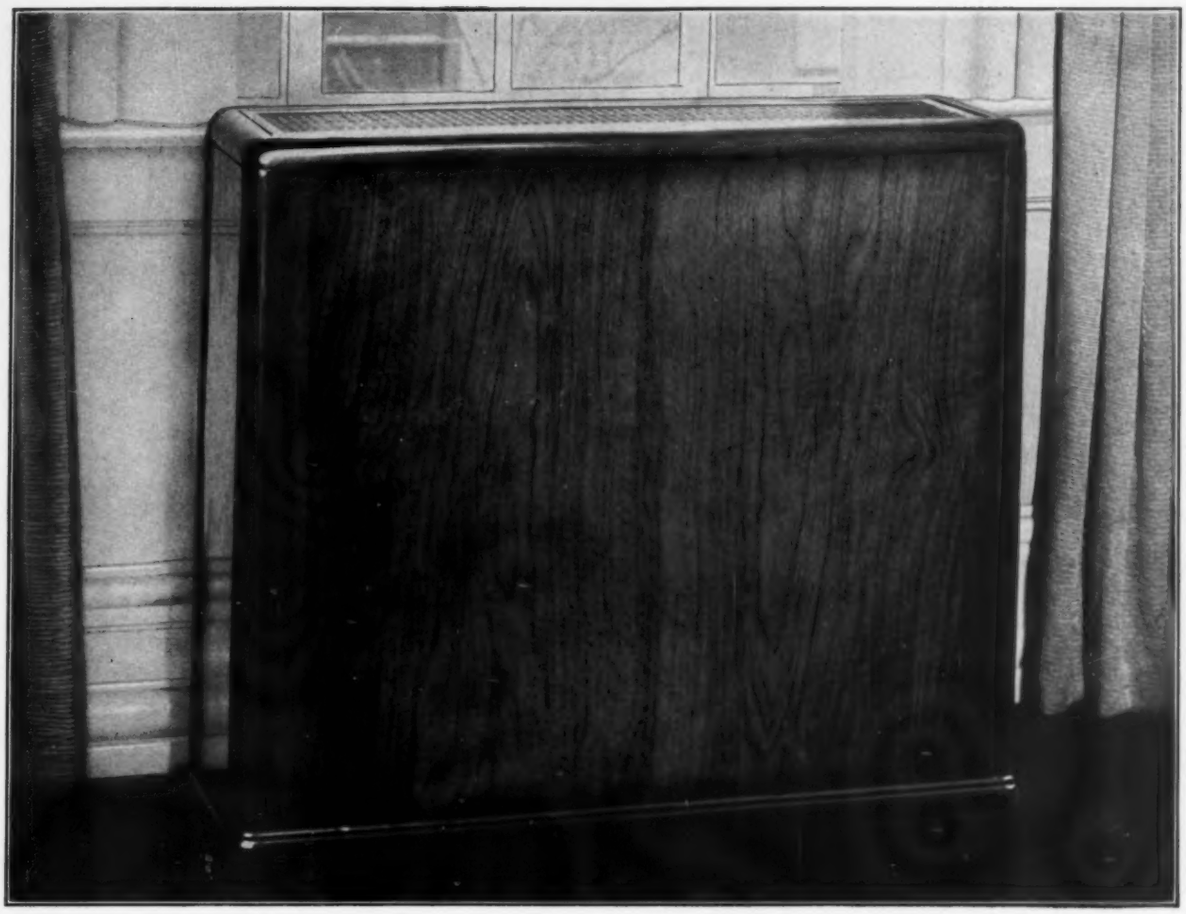

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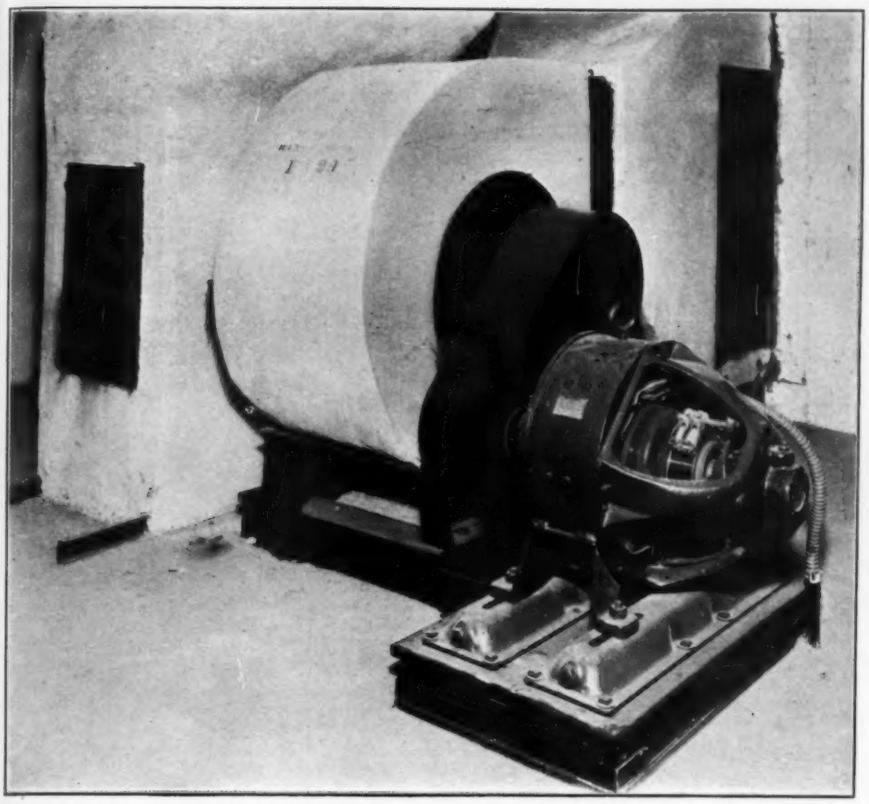

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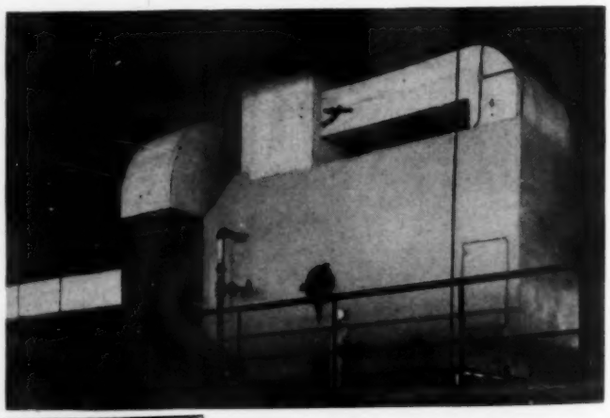

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Crane Co., Chicago, Ill.
Kennedy Valve Mfg. Co., Elmira, N. Y.
Midwest Piping & Supply Co., Inc. St. Louis, Mo.
Power Piping Co., Pittsburgh
Reading-Pratt & Cady Co., Inc., Bridgeport, Conn.
Taylor Forge & Pipe Works, Chicago
Tube Turns, Inc., Louisville, Ky.

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Crane Co., Chicago, Ill.
Grinnell Co., Inc., Providence, R. I.
Kennedy Valve Mfg. Co., Elmira, N. Y.
Midwest Piping & Supply Co., Inc., St. Louis, Mo.
Power Piping Co., Pittsburgh
Reading Iron Co., Reading, Pa.
Taylor Forge & Pipe Works, Chicago
Tube Turns, Inc., Louisville, Ky.

FITTINGS, SPRINKLER
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Grinnell Co., Inc., Providence, R. I.
Kennedy Valve Mfg. Co., Elmira, N. Y.
Tube Turns, Inc., Louisville, Ky.

FITTINGS, VACUUM
Kennedy Valve Mfg. Co., Elmira, N. Y.
Tube Turns, Inc., Louisville, Ky.

FITTINGS, WROUGHT IRON
A. M. Byers Co., Pittsburgh, Pa.

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Bonney Forge & Tool Works, Allentown, Pa.
Crane Co., Chicago, Ill.
Grinnell Co., Inc., Providence, R. I.
Midwest Piping & Supply Co., Inc., St. Louis, Mo.
Power Piping Co., Pittsburgh
Reading-Pratt & Cady Co., Inc., Bridgeport, Conn.
Roessing Mfg. Co., Sharpsburg, Pa.

FLANGES, CAST IRON
Lynchburg Foundry Co., Lynchburg, Va.

FLANGES, STEEL PIPE
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Reading-Pratt & Cady Co., Inc., Bridgeport, Conn.
Taylor Forge & Pipe Works, Chicago

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Nicholson & Co., W. H., Wilkes-Barre, Pa.

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Crane Co., Chicago, Ill.

GASKETS, ASBESTOS
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Air Reduction Sales Co., New York
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(See Boards, Gauge)

GAUGE GLASSES
(See Glasses, Gauge)

GAUGES, AIR
Crane Co., Chicago, Ill.

GAUGES, ALTITUDE
American Radiator Co., New York
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GAUGES, COMPOUND
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American Radiator Co., New York
Crane Co., Chicago, Ill.
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GAUGES, EXPANSION TANK
American Radiator Co., New York

GAUGES, INDICATING AND RECORDING
(See Instruments)

GAUGES, MERCURY
Grinnell Co., Inc., Providence, R. I.

GAUGES, OIL
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Grinnell Co., Inc., Providence, R. I.
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National Pipe Bending Co., New Haven, Conn.

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(See Systems)

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(See Machines)

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(See Machines)

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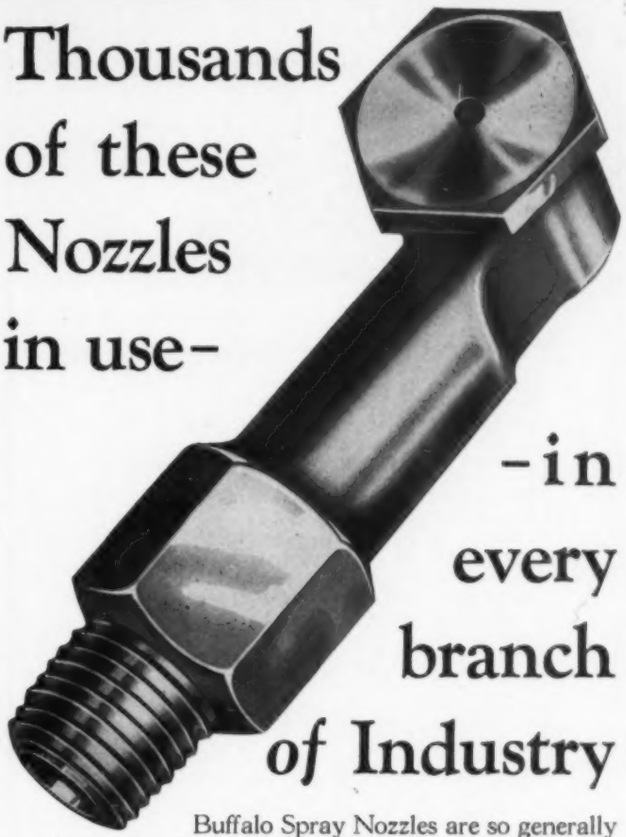

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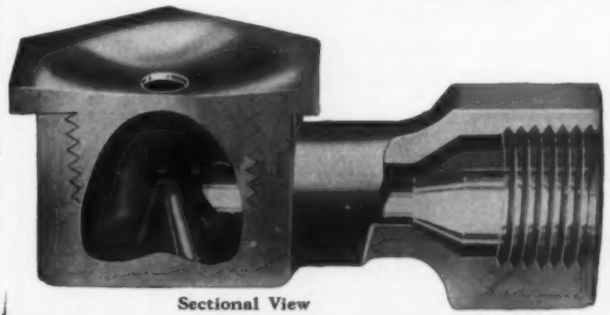

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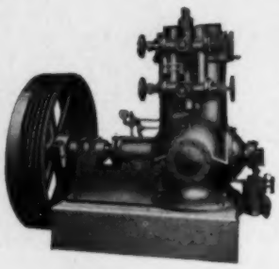

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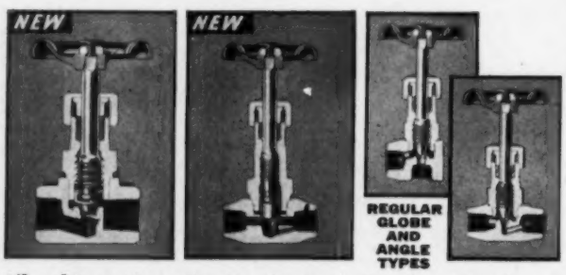

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Nelson Corp., Herman, Moline, Ill.

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Crane Co., Chicago, Ill.
Kewanee Boiler Corp., Kewanee, Ill.

RADIATORS, COPPER
Modine Mfg. Co., Racine, Wis.

RADIATORS, INDIRECT
American Radiator Co., New York

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Crane Co., Chicago, Ill.
Hoffman Specialty Co., Waterbury, Connecticut
Illinois Engineering Co., Chicago
Nash Engineering Co., So. Norwalk, Conn.
Roessing Mfg. Co., Sharpsburg, Pa.
Skidmore Corp., St. Joseph, Mich.

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Carbondale Machine Co., Carbondale, Pa.
Crane Co., Chicago, Ill.
Roessing Mfg. Co., Sharpsburg, Pa.
York Ice Machinery Corp., York, Pa.

REFRIGERATION, CENTRIFUGAL
Carrier Engineering Corp., Newark, N. J.

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(See Governors, Boiler Feed)

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Mason Regulator Co., Boston
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American Radiator Co., New York
Crane Co., Chicago, Ill.
Davis Regulator Co., Chicago
Illinois Engineering Co., Chicago
Mason Regulator Co., Boston
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Air Reduction Sales Co., New York

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Cook Electric Co., Chicago, Ill.
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Mason Regulator Co., Boston
Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.
Penn Heat Control Co., Philadelphia
Powers Regulator Co., Chicago
Sarco Co., Inc., New York City
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American Radiator Co., New York
Barber-Colman Co., Rockford, Ill.
Bristol Co., Waterbury, Conn.
Illinois Engineering Co., Chicago
Johnson Service Co., Milwaukee
Mason Regulator Co., Boston
Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.
Powers Regulator Co., Chicago
Sarco Co., Inc., New York City

REGULATORS, WELDING APPARATUS
Air Reduction Sales Co., New York
Linde Air Products Co., New York

REHEATERS, AIR
Nichols Products Corp., Detroit
Trane Co., The, La Crosse, Wis.

SAWS, HACK
Crane Co., Chicago, Ill.

SEPARATORS, AIR
Crane Co., Chicago, Ill.
Illinois Engineering Co., Chicago
Nicholson & Co., W. H., Wilkes-Barre, Pa.
Strong, Carlisle & Hammond Co., Cleveland

SEPARATORS, AMMONIA
Carbondale Machine Co., Carbondale, Pa.

SEPARATORS, OIL
Crane Co., Chicago, Ill.
Illinois Engineering Co., Chicago
National Pipe Bending Co., New Haven, Conn.
Strong, Carlisle & Hammond Co., Cleveland
Warren Webster & Co., Camden, New Jersey

SEPARATORS, STEAM
Crane Co., Chicago, Ill.
Illinois Engineering Co., Chicago
Power Piping Co., Pittsburgh
Strong, Carlisle & Hammond Co., Cleveland
Warren Webster & Co., Camden, N. J.

SHEET METAL WORK
Nichols Products Corp., Detroit

SHEETS, GALVANIZED, FLAT AND CORRUGATED
A. M. Byers Co., Pittsburgh, Pa.

SHEETS, STEEL, GALVANIZED
American Sheet and Tin Plate Co., Pittsburgh

SHEETS, STEEL
American Rolling Mill Co., The, Middletown, Ohio.
American Sheet and Tin Plate Co., Pittsburgh, Pa.
Youngstown Sheet & Tube Co., Youngstown, Ohio

SHEETS, WROUGHT IRON
A. M. Byers Co., Pittsburgh, Pa.

SHIELDS, VALVE STEM
York Ice Machinery Corp., York, Pa.

SOFTENERS, WATER, AUTOMATIC
Crane Co., Chicago, Ill.

SPRAY COOLING SYSTEMS
(See Systems)

SPRAY NOZZLES
(See Nozzles, Spray)

SPRINKLER HEADS
(See Heads, Sprinkler)

STEAM COCKS
(See Cocks, Steam)

STOCKS AND DIES
Crane Co., Chicago, Ill.

STOKERS
Detroit Stoker Co., Detroit

STOKERS, MECHANICAL
Detroit Stoker Co., Detroit

STOKERS, SIDE CLEANING
Detroit Stoker Co., Detroit

STOKERS, UNDERFEED
Detroit Stoker Co., Detroit

STOPS, ENGINE
Strong, Carlisle & Hammond Co., Cleveland

STRAINERS, STEAM
Illinois Engineering Co., Chicago
Sarco Co., Inc., New York City
Strong, Carlisle & Hammond Co., Cleveland.
Warren Webster & Co., Camden, N. J.

STRAINERS, WATER
Crane Co., Chicago, Ill.
Illinois Engineering Co., Chicago
Sarco Co., Inc., New York City
Strong, Carlisle & Hammond Co., Cleveland.

SUPPORTS, PIPE, CAST IRON
(For Underground Conduit)
Ric-wil Company, The, Cleveland

SWITCHES, PNEUMATIC
Powers Regulator Co., Chicago

SYSTEMS, AIR CONDITIONING
American Air Filter Co., Inc., Louisville, Ky.
American Blower Corp., Detroit
Buffalo Forge Co., Buffalo, N. Y.
Carrier Engineering Corp., Newark, N. J.
Clarage Fan Co., Kalamazoo, Mich.
Grinnell Co., Inc., Providence, R. I.
Maryland Air Conditioning Corp., Baltimore, Md.
Parks-Cramer Co., Fitchburg, Mass.
Trane Co., The, La Crosse, Wis.

SYSTEMS, AIR COOLING
American Blower Corp., Detroit
Buffalo Forge Co., Buffalo, N. Y.
Carrier Engineering Corp., Newark, N. J.
Clarage Fan Co., Kalamazoo, Mich.
Maryland Air Conditioning Corp., Baltimore, Md.
Trane Co., The, La Crosse, Wis.

SYSTEMS, AIR DRYING
Buffalo Forge Co., Buffalo, N. Y.
Carrier Engineering Corp., Newark, N. J.
Clarage Fan Co., Kalamazoo, Mich.
Maryland Air Conditioning Corp., Baltimore, Md.
Nichols Products Corp., Detroit
Trane Co., The, La Crosse, Wis.

SYSTEMS, AIR WASHING
American Blower Corp., Detroit
American Moistening Co., Providence, R. I.
Buffalo Forge Co., Buffalo, N. Y.
Carrier Engineering Corp., Newark, New Jersey
Clarage Fan Co., Kalamazoo, Mich.
Maryland Air Conditioning Corp., Baltimore, Md.

SYSTEMS, DRYING
Nichols Products Corp., Detroit
Silica Gel Corp., The, Baltimore, Md.

SYSTEMS, DUST COLLECTING
American Air Filter Co., Inc., Louisville, Ky.
American Blower Corp., Detroit
Buffalo Forge Co., Buffalo, N. Y.
Clarage Fan Co., Kalamazoo, Mich.
Garden City Fan Co., Chicago
Nichols Products Corp., Detroit

SYSTEMS, EXHAUST
American Blower Corp., Detroit
Buffalo Forge Co., Buffalo, N. Y.
Clarage Fan Co., Kalamazoo, Mich.
Nichols Products Corp., Detroit

SYSTEMS, HEATING, BLOWER
American Blower Corp., Detroit
Buffalo Forge Co., Buffalo, N. Y.
Clarage Fan Co., Kalamazoo, Mich.
Nichols Products Corp., Detroit

SYSTEMS, HEATING, INDUSTRIAL
Nichols Products Corp., Detroit

SYSTEMS, HEATING, VACUUM
Ames Pump Co., New York City
Barnes & Jones, Jamaica Plain, Massachusetts
Crane Co., Chicago, Ill.
Hoffman Specialty Co., Waterbury, Connecticut
Illinois Engineering Co., Chicago
Nash Engineering Co., So. Norwalk, Conn.
Sarco Co., Inc., New York City
Trane Co., The, La Crosse, Wis.
Warren Webster & Co., Camden, N. J.

SYSTEMS, HEATING, VAPOR
American District Steam Co., N. Tonawanda, New York
Barnes & Jones, Jamaica Plain, Massachusetts
Hoffman Specialty Co., Waterbury, Conn.
Illinois Engineering Co., Chicago
Sarco Co., Inc., New York City
Trane Co., The, La Crosse, Wis.
Warren Webster & Co., Camden, N. J.

SYSTEMS, HEATING, WATER
Barnes & Jones, Jamaica Plain, Massachusetts
Crane Co., Chicago, Ill.
Frank Heater & Eng. Co., Inc., O. E., Buffalo, N. Y.
Nash Engineering Co., So. Norwalk, Conn.

SYSTEMS, ICE WATER
Baker Ice Machine Co., Inc., Omaha, Nebr.
Carbondale Machine Co., Carbondale, Pa.

SYSTEMS, ICE WATER COOLING
Carbondale Machine Co., Carbondale, Pa.

SYSTEMS, INSULATION FOR UNDERGROUND PIPING
American District Steam Co., North Tonawanda, N. Y.
Ric-wil Company, Cleveland, O.

SYSTEMS, MULTIPLE UNIT REFRIGERATING
Baker Ice Machine Co., Inc., Omaha, Nebr.
Carbondale Machine Co., Carbondale, Pa.

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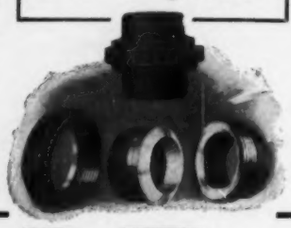

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Buffalo Forge Co., Buffalo, N. Y.

SYSTEMS, TEMPERATURE CONTROL
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American Radiator Co., New York
Barber-Colman Co., Rockford, Ill.
Bristol Co., Waterbury, Conn.
Carrier Engineering Corp., Newark, New Jersey
Foxboro Co., The, Foxboro, Mass.
General Electric Co., Schenectady, N. Y.
Illinois Engineering Co., Chicago
Johnson Service Co., Milwaukee
Maryland Air Conditioning Corp., Baltimore, Md.
Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.
Penn Heat Control Co., Philadelphia
Powers Regulator Co., Chicago
Sarco Co., Inc., New York
Trane Co., The, La Crosse, Wis.

SYSTEMS, VENTILATING
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Buffalo Forge Co., Buffalo, N. Y.
Carrier Engineering Corp., Newark, New Jersey
Clarage Fan Co., Kalamazoo, Mich.
Maryland Air Conditioning Corp., Baltimore, Md.
Nelson Corp., Herman, Moline, Ill.
Nichols Products Corp., Detroit
Trane Co., The, La Crosse, Wis.
Wing Mfg. Co., L. J., New York

TANKS, ACETYLENE GAS
Air Reduction Sales Co., New York
Linde Air Products Co., New York

TANKS, AMMONIA
Carbondale Machine Co., Carbondale, Pa.

TANKS, EXPANSION
American Radiator Co., New York

TANKS, RECEIVER
Warren Webster & Co., Camden, N. J.

TEMPERATURE CONTROL
(See Systems, Temperature Control)

THERMOMETERS, INDICATING AND RECORDING
(See Instruments, Indicating and Recording)

THERMOSTATS
(See Regulators, Room Temperature)

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Linde Air Products Co., New York

TORCHES, CUTTING, WELDING, OXY-ACETYLENE
Air Reduction Sales Co., New York
Linde Air Products Co., New York

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Buffalo Forge Co., Buffalo, N. Y

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Wagner Electric Corp., St. Louis, Mo.

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Anderson Co., The V. D., Cleveland, O.
Armstrong Machine Works, Three Rivers, Mich.

TRAPS, AMMONIA
Armstrong Machine Works, Three Rivers, Mich.
Carbondale Machine Co., Carbondale, Pa.

TRAPS, BLAST
American District Steam Co., North Tonawanda, N. Y.
American Radiator Co., New York
Armstrong Machine Works, Three Rivers, Mich.
Barnes & Jones, Jamaica Plain, Mass.
Crane Co., Chicago, Ill.
Hoffman Specialty Co., Waterbury, Conn.
Illinois Engineering Co., Chicago
Sarco Co., Inc., New York City
Strong, Carlisle & Hammond Co., Cleveland
Trane Co., The, La Crosse, Wis.
Warren Webster & Co., Camden, N. J.

TRAPS, GASOLINE
Anderson Co., The V. D., Cleveland, O.
Armstrong Machine Works, Three Rivers, Mich.

TRAPS, OIL AND GREASE
Armstrong Machine Works, Three Rivers, Mich.
Strong, Carlisle & Hammond Co., Cleveland

TRAPS, RADIATOR
(See Valves, Radiator Return Line)

TRAPS, STEAM
American District Steam Co., No. Tonawanda, N. Y.
Anderson Co., The V. D., Cleveland, O.
Armstrong Machine Works, Three Rivers, Mich.
Barnes & Jones, Jamaica Plain, Massachusetts
Crane Co., Chicago, Ill.
Hoffman Specialty Co., Waterbury, Conn.
Illinois Engineering Co., Chicago
Nicholson & Co., W. H., Wilkes-Barre, Pa.
Powers Regulator Co., Chicago
Sarco Co., Inc., New York City
Strong, Carlisle & Hammond Co., Cleveland
Trane Co., The, La Crosse, Wis.
Warren Webster & Co., Camden, N. J.

TRAPS, VACUUM
Armstrong Machine Works, Three Rivers, Mich.
Barnes & Jones, Jamaica Plain, Massachusetts
Crane Co., Chicago, Ill.
Illinois Engineering Co., Chicago
Nicholson & Co., W. H., Wilkes-Barre, Pa.
Sarco Co., Inc., New York City
Strong, Carlisle & Hammond Co., Cleveland
Trane Co., The, La Crosse, Wis.
Warren Webster & Co., Camden, N. J.

TUBE COUPLINGS
(See Couplings, Tube)

TUBES, BOILER
American Brass Co., New York.
Crane Co., Chicago, Ill.
Reading Iron Co., Reading, Pa.
Roessing Mfg. Co., Sharpsburg, Pa.

TUBING, ALUMINUM
Bush Mfg. Co., Hartford, Conn.

TUBING, ALUMINUM, FABRICATED
Bush Mfg. Co., Hartford, Conn.

TUBING, BRASS AND COPPER
Bush Mfg. Co., Hartford, Conn.
Crane Co., Chicago, Ill.

TUBING BRASS AND COPPER, FABRICATED
Bush Mfg. Co., Hartford, Conn.

TUBING, COPPER, FINNED
G & O Manufacturing Co., The, New Haven, Conn.

TUBING, STEEL, FINNED
Bush Mfg. Co., Hartford, Conn.

TUBING, WROUGHT IRON
A. M. Byers Co., Pittsburgh, Pa.

TURBO BLOWERS
(See Blowers, Turbo)

UNIONS
Dart Mfg. Co., E. M., Providence, R. I.
Youngstown Steel Products Co., The, Chicago

UNIT HEATERS
(See Heaters, Unit)

UNIT VENTILATORS
(See Ventilators, Unit)

VACUUM CLEANING APPARATUS
American Radiator Co., New York

VALVE RESEATING MACHINES
(See Machines)

VALVES, AIR LINE
Hoffman Specialty Co., Waterbury, Conn.
Kennedy Valve Mfg. Co., Elmira N. Y.

VALVES, AIR RELIEF
American Radiator Co., New York
Crane Co., Chicago, Ill.
Kennedy Valve Mfg. Co., Elmira, N. Y.

VALVES, ALARM FOR SPRINKLER SYSTEMS
Crane Co., Chicago, Ill.
Grinnell Co., Inc., Providence, R. I.
Kennedy Valve Mfg. Co., Elmira, N. Y.

VALVES, AMMONIA
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Baker Ice Machine Co., Inc., Omaha, Nebr.
York Ice Machinery Corp., York, Pa.

VALVES, ANGLE
Reading-Pratt & Cady Co., Inc., Bridgeport, Conn.
Scott Valve Mfg. Co., Detroit

VALVES, ANGLE, GLOBE AND CROSS
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Grinnell Co., Inc., Providence, R. I.
Kennedy Valve Mfg. Co., Elmira, N. Y.
Reading-Pratt & Cady Co., Inc., Bridgeport, Conn.
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Strong, Carlisle & Hammond Co., Cleveland

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Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.

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Crane Co., Chicago, Ill.
Davis Regulator Co., Chicago
Illinois Engineering Co., Chicago
Kennedy Valve Mfg. Co., Elmira, N. Y.
Linde Air Products Co., New York
Scott Valve Mfg. Co., Detroit

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Crane Co., Chicago, Ill.
Davis Regulator Co., Chicago
General Electric Co., Schenectady
Illinois Engineering Co., Chicago
Kennedy Valve Mfg. Co., Elmira, N. Y.
Strong, Carlisle & Hammond Co., Cleveland

VALVES, BLOW-OFF
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Kennedy Valve Mfg. Co., Elmira, N. Y.
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Yarnall-Waring Co., Philadelphia, Pa.

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Kennedy Valve Mfg. Co., Elmira, N. Y.

VALVES, CHECK
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Kennedy Valve Mfg. Co., Elmira, N. Y.
Reading-Pratt & Cady Co., Inc., Bridgeport, Conn.
Scott Valve Mfg. Co., Detroit

VALVES, CONTROL FOR GAS AND LIQUIDS
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Bristol Co., Waterbury, Conn.
General Electric Co., Schenectady
Kennedy Valve Mfg. Co., Elmira, N. Y.

VALVES, CONTROL FOR SPRINKLER SYSTEMS
Crane Co., Chicago, Ill.
Grinnell Co., Inc., Providence, R. I.
Kennedy Valve Mfg. Co., Elmira, N. Y.

VALVES, DIAPHRAGM
Kennedy Valve Mfg. Co., Elmira, N. Y.
Powers Regulator Co., Chicago

VALVES, DRY PIPE, FOR SPRINKLER SYSTEMS
Grinnell Co., Inc., Providence, R. I.
Kennedy Valve Mfg. Co., Elmira, N. Y.

VALVES, EXHAUST RELIEF
Davis Regulator Co., Chicago

VALVES, EXHAUST AND RELIEF
Crane Co., Chicago, Ill.
Illinois Engineering Co., Chicago
Kennedy Valve Mfg. Co., Elmira, N. Y.
Mason Regulator Co., Boston
Scott Valve Mfg. Co., Detroit

VALVES, FLOAT
Crane Co., Chicago, Ill.
Davis Regulator Co., Chicago
Illinois Engineering Co., Chicago
Kennedy Valve Mfg. Co., Elmira, N. Y.

VALVES, FLOAT, AMMONIA
Alco Valve Co., Inc., St. Louis, Mo.
Kennedy Valve Mfg. Co., Elmira, N. Y.

VALVES, FUEL OIL
Alco Valve Co., Inc., St. Louis, Mo.
Crane Co., Chicago, Ill.
Kennedy Valve Mfg. Co., Elmira, N. Y.
Reading-Pratt & Cady Co., Inc., Bridgeport, Conn.

VALVES, GAS REGULATING
Alco Valve Co., Inc., St. Louis, Mo.
Crane Co., Chicago, Ill.
Kennedy Valve Mfg. Co., Elmira, N. Y.
Strong, Carlisle & Hammond Co., Cleveland

VALVES, GATE
American District Steam Co., No. Tonawanda, N. Y.
American Radiator Co., New York
Crane Co., Chicago, Ill.
Jenkins Bros., New York
Kennedy Valve Mfg. Co., Elmira, N. Y.
Reading-Pratt & Cady Co., Inc., Bridgeport, Conn.
Scott Valve Mfg. Co., Detroit

VALVES, GATE, AMMONIA
Kennedy Valve Mfg. Co., Elmira, N. Y.

VALVES, GLOBE
Reading-Pratt & Cady Co., Inc., Bridgeport, Conn.
Scott Valve Mfg. Co., Detroit

VALVES, HEATING CONTROL, AIR
Kennedy Valve Mfg. Co., Elmira, N. Y.

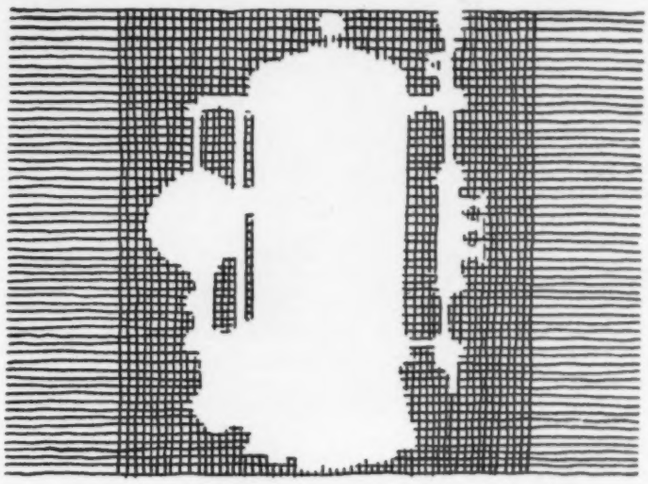
VALVES, HEATING CONTROL, ELECTRIC
Alco Valve Co., Inc., St. Louis, Mo.
American Radiator Co., New York
Barber-Colman Co., Rockford, Ill.
Illinois Engineering Co., Chicago
Kennedy Valve Mfg. Co., Elmira, N. Y.

VALVES, HYDRAULIC
Crane Co., Chicago, Ill.
Kennedy Valve Mfg. Co., Elmira, N. Y.
Reading-Pratt & Cady Co., Inc., Bridgeport, Conn.
Strong, Carlisle & Hammond Co., Cleveland
Scott Valve Mfg. Co., Detroit

VALVES, MODULATING OR GRADUATING
Hoffman Specialty Co., Waterbury, Conn.
Kennedy Valve Mfg. Co., Elmira, N. Y.

VALVES, MOTOR OPERATED
Alco Valve Co., Inc., St. Louis, Mo.
Barber-Colman Co., Rockford, Ill.
Reading-Pratt & Cady Co., Inc., Bridgeport, Conn.

VALVES, NEEDLE
Crane Co., Chicago, Ill.
Kennedy Valve Mfg. Co., Elmira, N. Y.
Reading-Pratt & Cady Co., Inc., Bridgeport, Conn.
Scott Valve Mfg. Co., Detroit



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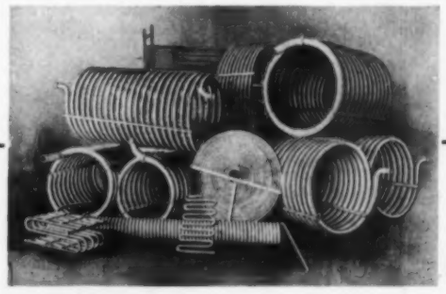

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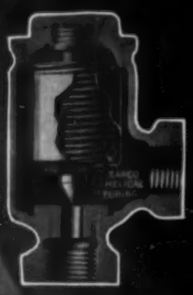

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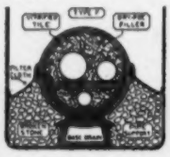

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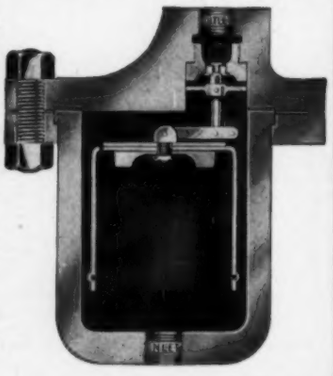

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Crane Co., Chicago, Ill.
Davis Regulator Co., Chicago
Illinois Engineering Co., Chicago
Kennedy Valve Mfg. Co., Elmira, N. Y.
Reading-Pratt & Cady Co., Inc., Bridgeport, Conn.
Scott Valve Mfg. Co., Detroit
Strong, Carlisle & Hammond Co., Cleveland

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Scott Valve Mfg. Co., Detroit

VALVES, PRESSURE REDUCING AND REGULATING
Air Reduction Sales Co., New York
American District Steam Co., No. Tonawanda, New York
Crane Co., Chicago, Ill.
Illinois Engineering Co., Chicago
Kennedy Valve Mfg. Co., Elmira, N. Y.
Linde Air Products Co., New York
Mason Regulator Co., Boston
Powers Regulator Co., Chicago
Strong, Carlisle & Hammond Co., Cleveland

VALVES, RADIATOR
American District Steam Co., No. Tonawanda, N. Y.
American Radiator Co., New York
Barnes & Jones, Jamaica Plain, Massachusetts
Crane Co., Chicago, Ill.
Hoffman Specialty Co., Waterbury, Connecticut
Illinois Engineering Co., Chicago
Kennedy Valve Mfg. Co., Elmira, N. Y.
Trane Co., The, La Crosse, Wis.
Warren Webster & Co., Camden, N. J.

VALVES, RADIATOR, AIR, AUTOMATIC
American Radiator Co., New York
Crane Co., Chicago, Ill.
Hoffman Specialty Co., Waterbury, Connecticut
Kennedy Valve Mfg. Co., Elmira, N. Y.
Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.
Sarco Co., Inc., New York City

VALVES, RADIATOR, RETURN LINE
American District Steam Co., No. Tonawanda, N. Y.
American Radiator Co., New York
Barnes & Jones, Jamaica Plain, Massachusetts
Crane Co., Chicago, Ill.
Hoffman Specialty Co., Waterbury, Connecticut
Illinois Engineering Co., Chicago
Kennedy Valve Mfg. Co., Elmira, N. Y.
Sarco Co., Inc., New York City
Strong, Carlisle & Hammond Co., Cleveland
Trane Co., The, La Crosse, Wis.
Warren Webster & Co., Camden, N. J.

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American Radiator Co., New York
Crane Co., Chicago, Ill.
Illinois Engineering Co., Chicago
Kennedy Valve Mfg. Co., Elmira, N. Y.
Mason Regulator Co., Boston
Scott Valve Mfg. Co., Detroit

VALVES, SAFETY
Crane Co., Chicago
Kennedy Valve Mfg. Co., Elmira, N. Y.
Scott Valve Mfg. Co., Detroit

VALVES, SOLENOID
Alco Valve Co., Inc., St. Louis, Mo.
General Electric Co., Schenectady

VALVES, STOP AND CHECK
(See Valves, Non-Return)

VALVES, TEMPERATURE CONTROL
Alco Valve Co., Inc., St. Louis, Mo.
Capitol Brass Division of Bohn Aluminum & Brass Corp., Detroit.

VALVES, THREE AND FOURWAY
Crane Co., Chicago, Ill.
Kennedy Valve Mfg. Co., Elmira, N. Y.
Nicholson & Co., W. H., Wilkes-Barre, Pa.

VALVES, THROTTLE
Kennedy Valve Mfg. Co., Elmira, N. Y.
Reading-Pratt & Cady Co., Inc., Bridgeport, Conn.
Strong, Carlisle & Hammond Co., Cleveland

VALVES, VACUUM BREAKING
Kennedy Valve Mfg. Co., Elmira, N. Y.
Scott Valve Mfg. Co., Detroit
Skidmore Corp., St. Joseph, Mich.

VALVES, VENTING, FOR RETURN MAINS
(See Vents, Air Heating)

VENTILATING SYSTEMS
(See Systems, Ventilating)

VENTILATORS, FLOOR
Clarage Fan Co., Kalamazoo, Mich.

VENTILATORS, MUSHROOM
Clarage Fan Co., Kalamazoo, Mich.
Nichols Products Corp., Detroit

VENTILATORS, ROOF
Clarage Fan Co., Kalamazoo, Mich.
Wing Mfg. Co., L. J., New York

VENTILATORS, UNIT
Diehl Mfg. Co., Elizabethport, N. J.
Trane Co., The, La Crosse, Wis.
Wing Mfg. Co., L. J., New York

VENTS, AIR, HEATING
American Radiator Co., New York
Hoffman Specialty Co., Waterbury, Connecticut
Sarco Co., Inc., New York
Trane Co., The, La Crosse, Wis.

VENTS, TRAP, STEAM
American District Steam Co., No. Tonawanda, New York
Barnes & Jones, Jamaica Plain, Massachusetts
Hoffman Specialty Co., Waterbury, Connecticut
Sarco Co., Inc., New York
Trane Co., The, La Crosse, Wis.
Warren Webster & Co., Camden, N. J.

WALL BOXES, DIRECT-INDIRECT RADIATOR
(See Boxes)

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American Moistening Co., Providence, R. I.
Buffalo Forge Co., Buffalo, N. Y.
Carrier Engineering Corp., Newark, N. J.
Maryland Air Conditioning Corp., Baltimore, Md.
Nichols Products Corp., Detroit

WATER HEATERS
(See Heaters)

WATER LEVEL CONTROLS
(See Controls, Water Level)

WATER LEVEL INDICATORS
(See Indicators, Water Level)

WATER SOFTENERS
(See Softeners, Water, Automatic)

WELDING EQUIPMENT
Air Reduction Sales Co., New York
General Electric Co., Schenectady
Linde Air Products Co., New York
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

WELDING FLUXES
Air Reduction Sales Co., New York
Linde Air Products Co., New York

WELDING ROD
Air Reduction Sales Co., New York
American Brass Co., New York.
Linde Air Products Co., New York

WHISTLES
Crane Co., Chicago, Ill.

WIRE, WELDING
Air Reduction Sales Co., New York
Linde Air Products Co., New York

WRENCHES, PIPE
Bonney Forge & Tool Works, Allentown, Pa.
Crane Co., Chicago, Ill.

WRENCHES, SPUD, RADIATOR
American Radiator Co., New York

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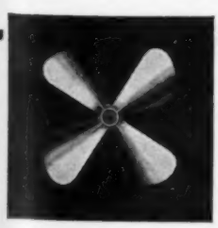
TORRINGTON



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* For every kind of equipment on which fans are used. • Completely assembled, balanced and tested, ready to mount on motor shaft.

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ARMSTRONG TRAPS (Original Inverted Bucket Type)

For any capacity and for any use

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Stocks in all Principal Cities

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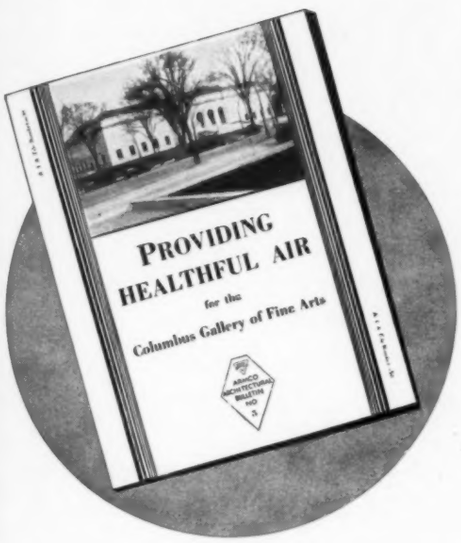
You can CHOOSE

THE RIGHT METAL FOR EVERY PURPOSE



This is one of a series of Armco Architectural Bulletins, devoted to modern heating, ventilating, and air-conditioning systems. Write for a copy of Bulletin A-118, or, if you wish, for the entire series.

WHATEVER THE SERVICE CONDITIONS may be in that heating, ventilating or air-conditioning system you are designing, there is a grade of Armco sheet metal that will give you the result you want, and economically, too.

For mild or neutral exposures, Armco galvanized steel sheets are sufficiently durable — and inexpensive, in ducts, risers, plenum chambers, and ventilators. But where corrosion threatens any part of the system, rust-resisting Ingot Iron is the safest specification. And it costs but little more.

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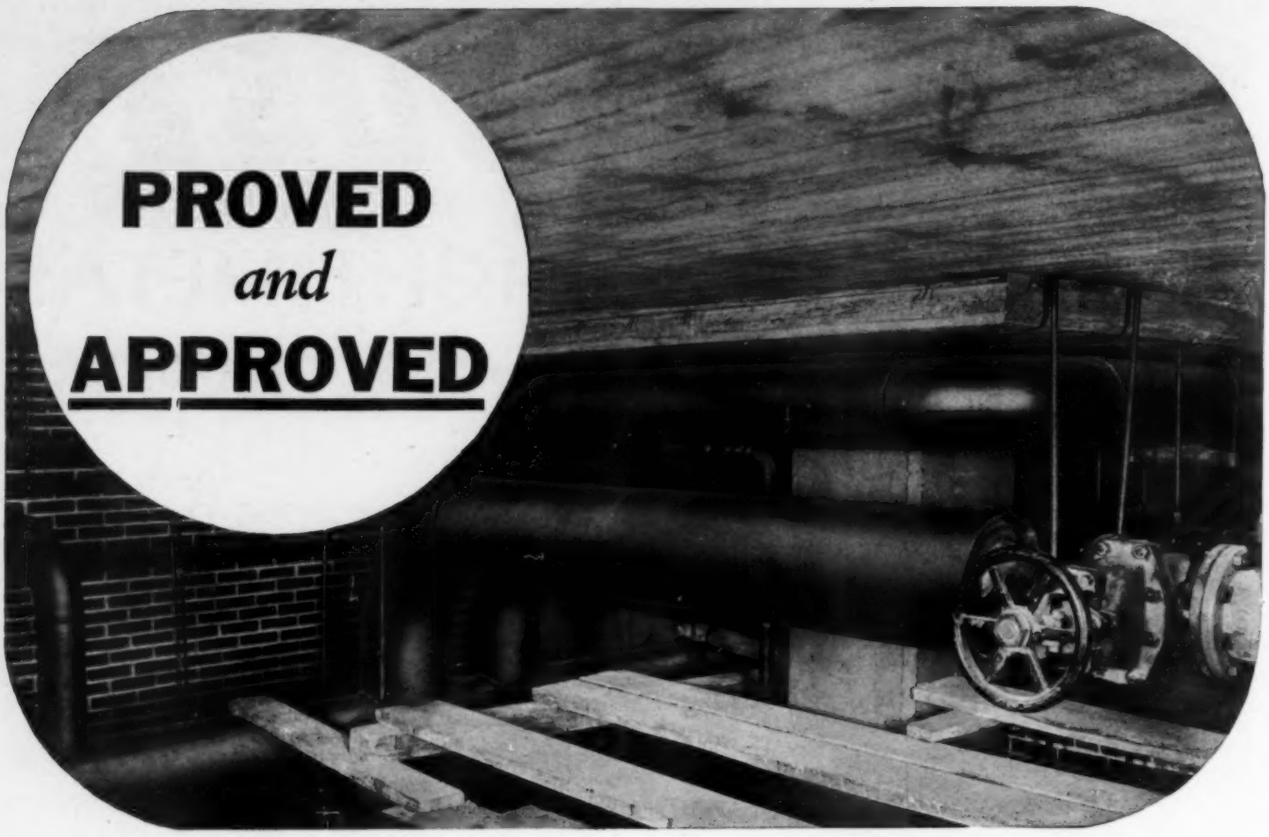
SHEETS ▼ PLATES ▼ SPIRAL PIPE

ARMCO



14" steam header and main steam line, welded with Tube-Turns, in Bell Telephone Bldg., Louisville. Redmon Heating Co., Louisville, Contractors.

WHENEVER you're in the market for fittings, we believe it will pay you to remember that *there are no "bugs" in Tube-Turns.*

Even before welding was generally recognized or practiced in the United States, Tube-Turns were widely and successfully used in Europe. And for the past five years in this country, thousands upon thousands of Tube-Turns have been in the severest service that leading oil, process and industrial companies could give them—*with never a single failure.*

In all these years, no Tube-Turn customer has ever suggested even one change that would be desirable in these peerless fittings. From the first, their *uniform walls**, their ideal radius, their entire design has met with complete satisfaction.

Tube-Turns are made by the one known process that takes fine, seamless tubing and converts it into fittings that match the pipe in every respect. In fact, Tube-Turns are a little *better* than the original tubing because the extra forging process and annealing add strength and reduce stress. May we send you complete facts? *Address:* Tube-Turns, *Incorporated,* 1309 S. Shelby St., Louisville, Ky.

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UNIFORM★ WALL-THICKNESS

is *essential* in obtaining

(1) Satisfactory Joints. Regardless of the workmanship or materials used, no welder can consistently make good joints unless the fitting lines up with the pipe—*in O. D., I. D., and wall thickness.* . . . Thickened walls also increase time and cost of welding.

(2) Full-Life Piping. Corrosion and erosion are always most severe at *the back* (outside) *wall* of a fitting. Thinning at this point *reduces life.*

★Tube-Turns have *uniform wall-thickness*—ALWAYS within A. S. T. M. tolerances *at all points.* No thinning of outside walls. No thickening of inside walls.

Heating · Piping
and Air Conditioning

In
MINNEAPOLIS

MODERNIZATION *of store proves fine investment.*

$9,179.33 of $12,924.00 invested returned to owner in first year of operation.

PRIOR to 1930 the heating of L. S. Donaldson Company's Department Store in Minneapolis was expensive and unsatisfactory. One portion of the store was heated by a one-pipe system and the other by an obsolete vacuum system, both using steam purchased from a nearby building.

The Webster Branch Office, after a study of the equipment, recommended a modernization program. The installation was converted to an Improved Webster Vacuum System with Webster Moderator Control.

In less than a season this modernized installation, with heating "Controlled-by-the-Weather", had shown a splendid return on the investment due to reduced steam consumption, and in addition a comfortable, *even* temperature appreciated by both customers and employees.

The experience of the Donaldson Store is one more indication of the profit-possibilities of well-directed modernization. We will be glad to submit details concerning the equipment and performance of this Improved Webster System Installation.

Warren Webster & Company, Camden, N. J.
Pioneers of the Vacuum System of Steam Heating
Branches in 60 principal U. S. Cities—Established 1888.
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IMPROVED Webster Systems of Steam Heating

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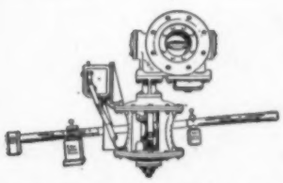
Webster Central Controls for use with IMPROVED WEBSTER SYSTEMS of STEAM HEATING

ROOF THERMOSTAT
Provides the true "Control-by-the-Weather" feature of Webster Moderator Control.

VARIATOR CONTROL
Provides convenient supplementary manual control in Moderator Systems. Facilitates proper operation. Provides for quick heating up in morning and reduced heating rate at night.



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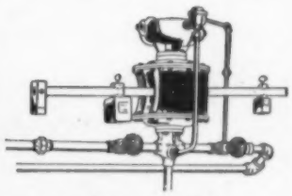
A semi-automatic Steam Heat Control anybody can understand. Sliding weights readily adjusted for Cold Weather, Moderate Weather, Mild Weather or Quick Heating Up.



WEBSTER HYLO VACUUM VARIATOR
Another simple central control. Used with Improved Webster Vacuum Systems.

Some of the ducts and blowers in the new Chemistry Building of Fisk University. 3,000 lbs. of Everdur were used in the 22 blowers and housings, supplied by the I L G Electric Ventilating Co. Another 6,000 lbs. of Everdur were used in the ducts, construction of which utilized the single-lock and soldered type of joints. Rock City Construction Co., Nashville, *General Contractor;* T. L. Herbert & Son, Nashville, *Ventilating Contractor;* Henry C. Hibbs, *Architect.*

EVERDUR *Ducts and Blowers...*

carry corrosive fumes from Chemical Laboratories, *Fisk University*

The duct system conveying corrosive gases from the laboratories in the Chemistry Building of Fisk University, Nashville, is made of Everdur (copper, alloyed with silicon and manganese). This exclusive Anaconda Metal offers excellent resistance to a great number of corroding agents . . . is really welded by usual methods . . . and is considered *ideal* for such service.

About the workability of Everdur, T. L. Herbert & Sons, ventilating contractor, writes: "Our first experience with Everdur was on the Fisk University job. Since then we have used it for several other purposes. We find Everdur a very tough metal, but easily workable into different forms. We believe any concern will be more than pleased with the fabricating properties of Everdur."

The great strength of Everdur (equal to that of mild steel) makes possible the substitution of thinner sheets of this highly corrosion-resistant alloy for many applications.

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EVERDUR . . . *an* ANACONDA METAL

The EDITOR'S PAGE

Heating · Piping *and* Air Conditioning

THIS MONTH—

The first article in this issue is F. E. Wertheim's "Leak-Tight Joints—600 to 550,000 Lb." In it the author describes a number of types of pipe joints for use with high-pressure steam, air and other fluids which have demonstrated their reliability under operating conditions. Design of joints which will remain tight in service is a

major problem and the aim of Mr. Wertheim's article is to present helpful data concerning them. Following this informative paper, a brief article on page 473 tells how a temperature control problem involving an instantaneous heater supplying process water—steam being supplied from a turbine—was satisfactorily solved.

The next article, written by H. C. Weller, is "Utilizing Waste Gases for Factory Heating." The Gem Clay Forming Company saves $7500.00 per year by using waste heat from a continuous pottery kiln for heating and drying. The system is described by Mr. Weller, and a discussion on comfort and health in a plant heated in this manner is included, as is material on the necessary computations for determining the heat available.

Misconceptions as to what the Hartford loop is and what it does are prevalent; Robert E. Hattis endeavors to clarify the function of this piping arrangement in his interesting paper which starts on page 483. He shows an adapted form of the loop which he has used on a number of jobs. Mr. Hattis' article is followed by George W. Ott's description of the ventilating features of the new Chicago post office, an outstanding mail-handling center. This is an "air-rights" building and removal of locomotive smoke from the railroad tracks under the building is one of the ventilation problems.

Junius D. Edward's article on page 478 tells of the heating, piping and ventilating problems met with in a modern industrial research laboratory, and describes the Aluminum Research Laboratories; such factors as removal of fumes, flexibility

of piping, etc., are of prime importance in such buildings. Following this laboratory article, Malcolm Tomlinson shows how drying economy is aided by vapor proofing drying rooms.

In "On the Job" several short articles of particular interest to the operating, installing and maintenance engineer are published. The importance of operating valves with care is discussed by W. H. Wilson; need for the proper design of refrigerating coils is Robert S. Wheaton's subject; George T. Condron points out possible economies that may be obtained by the installation of a vacuum pump; John A. Masek describes an installation for conditioning paper.

There's no depression as far as the developments in air conditioning, heating and piping equipment are concerned; starting on page 526 of this issue a number of interesting developments and improvements are described. There are several new room coolers; improved valves; some pumps you'll want to know about and a number of other devices.

NEXT MONTH—

Of interest to engineers concerned with heating is the paper which has been prepared by C. E. Joos and V. A. Rohlin on corrosion of hot water lines and its correction; divided into several installments, the first of this valuable series will appear next month. Use of deareating equipment is discussed in detail.

Oil-handling stations and many industrial plants require provisions for heating heavy oils so that they may be handled quickly and economically. In his article to appear in the August issue, Samuel R.

Lewis discusses piping steam for heating oil tanks, describing effective piping lay-outs and pointing out the factors to consider.

In high-humidity rooms in paper mills, weaving rooms, dye houses, etc., a properly insulated roof to eliminate condensation and drip in order to prevent spoilage is of importance. In an article by Ralph Winslow to be published next month, a chart for selecting the proper thickness of insulation is presented and the experience of two mills is described.